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DEPARTMENT OF THE INTERIOR, CANADA
Hon. ARTHUR MEIGHEN, *Minister*, W. W. CORY, *Deputy Minister*.
GEODETIC SURVEY OF CANADA
NOEL OGILVIE, *Superintendent*.

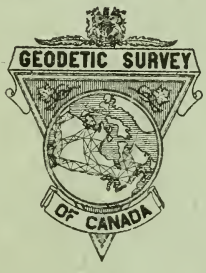
PRECISE LEVELLING

CERTAIN LINES IN QUEBEC, ONTARIO and BRITISH COLUMBIA

WITH AN INDEX MAP SHOWING ALL WORK PREVIOUSLY PUBLISHED

PUBLICATION No. 1

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APR 15 1920



OTTAWA
J. de LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1918

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HON. ARTHUR MEIGHEN, *Minister*, W. W. CORY, *Deputy Minister*.
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F. B. REID Supervisor of Levelling

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CONTENTS

	Page
Introduction	5
Descriptions of Bench-Marks:—	
Rouse Point, N.Y. to Sherbrooke, Que.	8
Ste. Rosalie Junction to Farnham, Que.	10
Chaudière to Richmond, Que.	11
Loop line around Montreal, Que.	12
Brantford to Lucan Crossing, Ont.	14
Guelph Junction to Palmerston, Ont.	16
Fergus to Melville, Ont.	16
Port Dalhousie and Port Colborne, Ont.	17
Franz to Port Arthur, Ont.	17
Jasper, Alta. to Loos, B.C.	22
Abbotsford to Resplendent, B.C.	23
Revelstoke to Kamloops, B.C.	29
Elevations, Table of	32
Rail Elevations	46
Index	53
Map	66

INTRODUCTION

This publication on Precise Levelling is the first one issued by the Geodetic Survey of Canada as a separate branch of the Department of the Interior. Precise levelling results previously issued to the public are contained in six "Publications of the Dominion Observatory", as follows:—

Vol. I, No. 2, issued 1912*	Vol. II, No. 1, issued 1915
Vol. I, No. 3, " 1913	Vol. III, No. 6, " 1916
Vol. I, No. 8, " 1914	Vol. III, No. 8, " 1917

The present publication is arranged in the same general form as the previous ones, with the results of the levelling set forth in three tables. The index and map included herein are complete for all the work previously published, as well as that in the present publication; the index indicates in which publication descriptions and elevations of bench-marks published before this may be found.

Table I indicates the routes followed between terminal points and gives complete descriptions of all bench-marks established along these routes.

Table II shows in the first two columns the numbers of the bench-marks; in the third and fourth columns the approximate distance (in miles) between bench-marks, and from the initial bench-mark of the line; the fifth and sixth columns (headed "Discrepancy") give the difference (in feet) between the forward levelling and the backward levelling for each section between bench-marks and the accumulated difference from the initial bench-mark. The seventh column gives the elevations of the bench-marks shown in the second column; for convenience, these bench-marks are repeated (in the eighth column) in order that the number of any bench-mark and its elevation may be in adjoining columns. In this table are shown also the elevations determined by the Geodetic Survey of Canada for certain bench-marks established by other surveys and connected with the former.

Table III shows the elevations at railway stations and at crossings of intersecting railways; also on the bridges over rivers and lakes and the more important streams. Rail elevations were in all cases taken on top of the rail, in front of the telegraph office at telegraph stations and opposite the shelter or platform at flag-stations.

The results are given for the following lines:—

1. Rouse Point, N.Y. to Sherbrooke, Que.
2. Ste. Rosalie Junction to Farnham, Que.
3. Chaudière to Richmond, Que.
4. Loop line around Montreal, Que.
5. Brantford to Lucan Crossing, Ont.
6. Guelph Junction to Palmerston, Ont.
7. Fergus to Melville, Ont.
8. Port Dalhousie and Port Colborne, Ont.
9. Franz to Port Arthur, Ont.
10. Jasper, Alta., to Loos, B.C.
11. Abbotsford to Resplendent, B.C.
12. Revelstoke to Kamloops, B.C.

Line 1 was started from the United States Coast and Geodetic Survey bench-mark in the Chapman Block, Rouse Point, N.Y.; levels were carried via St. Lambert, Ste. Rosalie Junction and Richmond, being closed at Sherbrooke on

*Levelling in Yukon territory only.

the original Rouse Point-Sherbrooke line—carried via St. Johns, Farnham and Magog (see 1917 publication, line *c*). The closing error of the circuit formed by the two lines from Rouse Point to Sherbrooke is 0·279 foot—the difference between the two elevations for the junction bench-mark at Sherbrooke. Line 2 divides this circuit into two smaller ones, the closing errors being respectively 0·104 foot and 0·175 foot. Line 3 was started from the St. Anselme–Levis line (1916 publication) and terminated at Ricmond, with a small closing error, on line 1.

Line 4 branches from line 1 at St. Lambert and after crossing the Victoria bridge over the St. Lawrence river forms a complete loop around the main portion of the city of Montreal, closing upon itself at bench-mark DLXXXIV, at the Point St. Charles end of the Victoria bridge. Nineteen bench-marks were established along the course of the line and in addition several bench-marks of the Public Works Department of Canada were tied in; tables I and II in this publication give descriptions and elevations of all bench-marks, those originally established by the Public Works Department being designated by Roman numerals. The route taken by the loop line from bench-mark DLXXXIV was as follows: the tracks of the Grand Trunk railway were followed through Point St. Charles and St. Henri to the crossing of Atwater avenue; Atwater avenue was then followed to the subway under the Canadian Pacific railway's Montreal-Smiths Falls line; a spur line was run from this point to Dominion Square while the main line of levels was continued along the Canadian Pacific railway through Montreal West, Côte-des-Neiges and Mile End to the Place Viger station; the streets along the water front were then followed till the line closed upon itself at the above mentioned bench-mark. The closing error of 0·087 foot has been distributed equally around the loop at the rate of 0·004 foot per mile—the distance being $21\frac{3}{4}$ miles.

The 1913 publication gave results for a large circuit of levelling in western Ontario extending through Toronto, Brantford, London, Palmerston and Owen Sound. Lines 5, 6 and 7 given herewith, split this circuit into four small ones, all having fairly small closures. Line 5 was started from the main Toronto-Windsor line near Brantford, line 6 is a branch from line 5 and line 7 a branch from line 6, each being terminated at a point on the circumference of the large circuit. Under line 8 are included two short branch lines from the Hamilton-Bridgeburg line (1913 publication), namely: St. Catharines to Port Dalhousie and Welland Junction to Port Colborne; these were run primarily for the purpose of forming a connection between the Geodetic Survey levels in the Niagara peninsula and the levels established by the Hydrographic Survey, Department of the Naval Service, by means of water transfers across the great lakes. The elevation of the Hydrographic Survey's bench-mark at Port Dalhousie, derived by water transfers between the years 1911 and 1914 from the automatic gauge at Tibbets Point, N.Y., is 250·421, and the elevation of their bench-mark at Port Colborne, derived by water transfers between the same years from automatic gauges at Buffalo and Cleveland, is 584·688; the elevations obtained by the line of precise levels of the Geodetic Survey of Canada from Rouse Point, via Toronto and Hamilton, are 249·812 and 583·994 respectively. This means that the difference between the Port Dalhousie and Port Colborne bench-marks of the Hydrographic Survey, as established by precise levelling, is 334·182 feet.

Line 9 is a continuation of the line from Steelton to Franz which was published last year; at Port Arthur it closes upon the line from Stephen, Minn., thus forming the first connection by precise levelling through Canada between the United States Coast and Geodetic Survey bench-marks at Rouse Point, N.Y., and Stephen, Minn. At Port Arthur this line is connected with a bench-mark of the Hydrographic Survey; the elevation of this, derived by water transfers between the years 1907 and 1914 from Marquette, Mich., is 616·154; the elevation obtained by the line of precise levels of the Geodetic Survey of Canada

from Rouse Point is 614·456. To recapitulate, connections have now been made between water-transfer bench-marks and the precise level system of the Geodetic Survey of Canada at the following points on the great lakes: Kingston, Brighton, Toronto and Port Dalhousie on lake Ontario, Port Colborne on lake Erie, Goderich on lake Huron, Michipicoten and Port Arthur on lake Superior.

Line 10 is a continuation of the Saskatoon-Wainwright-Edmonton-Jasper line (1915–16–17 publications). Line 11 was started at Abbotsford, B.C., from the levels previously run along the Great Northern railway from Vancouver (1916 publication). By means of this line the mean sea level datum established at Vancouver by the Tidal and Current Survey is extended inland to Resplendent —only a short distance from the Yellowhead pass—and a junction made with levels from Stephen, Minn. It is to be observed that the difference shown at the junction point—refer to Table II—is only 0·049 foot. Line 12 completes the Calgary-Field-Revelstoke line (1916 and 1917 publications) and establishes another junction with the Stephen levels—namely at Kamloops, B.C. The closure at this point, 1·094 feet, is not so satisfactory as at Resplendent. This may be in a large measure due to the closing error of slightly over one foot in the twelve hundred mile circuit in Saskatchewan and Alberta—refer to the introduction to the 1916 publication.

As in previous publications all elevations are instrumental and have had no adjustments applied to them, with the single exception of the loop line around the city of Montreal where the small closing error was distributed proportionately to the distance in order to avoid confusion to engineering organizations using the bench-marks.

The standard bench-mark adopted consists of a copper bolt, three-quarters of an inch in diameter and four inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench-mark). The bolt is sunk horizontally in rock or masonry so that only the circular end is visible.; the number of the bench-mark is stamped on this end as well as the letters mentioned above, and a horizontal chisel line is cut, upon which the elevation is taken. At certain points concrete bench-mark piers have been built; these project from six inches to one foot above the ground and extend below the frost line; in all piers built previous to 1917 the copper bolt upon which the elevation was taken was placed horizontally in a side of the pier, about nine inches below the top. In 1917 a new design was adopted, the bolt being placed vertically in the top of the pier. The description indicates in each case the position of the bolt.

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TABLE I

BENCH-MARKS BETWEEN ROUSE POINT, N.Y., AND SHERBROOKE, QUE., VIA NAPIERVILLE JUNCTION RAILWAY TO DELSON AND GRAND TRUNK RAILWAY THROUGH ST. LAMBERT AND RICHMOND TO SHERBROOKE.

Elevations on page 32.

Note.—These descriptions are written with the assumption that the railway runs in a northerly direction from Rouse Point to St. Lambert, thence easterly to Richmond and thence southerly to Sherbrooke.

⊕ United States Coast and Geodetic Survey bench-mark in Chapman Block, Rouse Point.

581-B In north face—5 inches above concrete base—of international boundary monument No. 647, 66 feet west of Grand Trunk railway track, 1 mile north of Rouse Point and on south line of roadway along boundary.

582-B In north end of east face of concrete coping on east end of pipe culvert under Napierville Junction railway, 2 miles south of Lacolle and 100 feet south of mile post 3 from international boundary.

583-B In east end of north face of concrete retaining wall behind south abutment of subway under Napierville Junction railway, 400 feet south of Lacolle station.

584-B In northwest face of southwest wing wall of concrete culvert under King Edward highway, 2 miles north of Lacolle and 500 feet northeast of crossing of Napierville Junction railway.

585-B In east end of north face of south concrete abutment of open culvert under Napierville Junction railway, 4¼ miles north of Lacolle and 345 feet north of mile post 9 from international boundary.

586-B In west end of south face—10 inches below top—of concrete retaining wall behind south abutment of Napierville Junction railway bridge, 400 feet north of Napierville station.

587-B In second course of stonework below water-table course, in north face of pilaster at northeast corner of Napierville Roman Catholic church.

588-B In east end of south face of north concrete abutment of open culvert under Napierville Junction railway, 3¼ miles north of Napierville and at mileage 15·7 from international boundary.

589-B In south end of west face—30 inches below top—of southwest concrete retaining wall of plate-girder bridge on Napierville Junction railway, 900 feet south of St. Edouard station.

590-B In east end of north face of south concrete abutment of open culvert under Napierville Junction railway, 450 feet south of La Tortue flag-station.

591-B In south end of east face—9 inches below coping—of east concrete face-wall of pipe culvert under Napierville Junction railway, ¾ mile north of La Tortue flag-station and midway between two farm crossings about 500 feet apart.

592-B In north face of southeast concrete retaining wall—5 feet below bridge seat—of plate-girder bridge on Napierville Junction railway, 1¼ miles south of Delson and at mileage 26·15 from international boundary.

593-B In side of concrete bench-mark pier, 3 feet east of west line of Napierville Junction railway right of way, 60 feet north of a private crossing and 1,250 feet southeast of Canadian Pacific station at Delson. This is beside the easterly track of the loop at Delson, i.e., the track which connects with the Canadian Pacific railway.

594-B In north end of west face of east abutment of square concrete culvert under Canadian Pacific railway, immediately west of diamond crossing of Grand Trunk railway at Delson.

595-B In east face of flat boulder beside ditch, 12 feet east of west line of Grand Trunk railway right of way, 3 miles north of Delson, 60 feet north of a farm crossing and 1,800 feet north of mile post 16 from Montreal.

596-B In second altar-step below top, in northeast face of northeast retaining wall of plate-girder bridge on Grand Trunk railway, 1¼ miles north of Laprairie and 340 feet south of mile post 13 from Montreal.

597-B In top course of stonework, in west face of north abutment of large open culvert under Grand Trunk railway, 1¾ miles south of St. Lambert and 0·6 mile south of diamond crossing of Montreal and Southern Counties (electric) railway.

597–B–2 In third course of stone work below water table course, in east face of pilaster at east end of front (or south) wall of St. Lambert post office.

598–B In south face of concrete extension of top course of stonework in west abutment of open culvert under Grand Trunk railway in Southwark yard, 1 mile east of St. Lambert and 1,000 feet east of a highway crossing.

599–B In north end of west face of stone retaining wall behind east abutment of open culvert under Grand Trunk railway, 1 mile west of St. Hubert and 320 feet west of "Yard Limit" post at east end of Southwark yard.

600–B In water table course of stonework, in east face of buttress at east end of front (or south) wall of Roman Catholic church, St. Hubert.

601–B In north end of west face of stone retaining wall behind east abutment of plate-girder bridge on Grand Trunk railway, 1½ miles west of St. Bruno and immediately east of a highway crossing.

602–B In west end of south face of concrete coping on south end of stone culvert under Grand Trunk railway, immediately west of St. Bruno station.

603–B In first course of stonework below coping, in west end of north face of square stone culvert under Grand Trunk railway, 1 mile west of St. Bazile, 700 feet east of a highway crossing and 550 feet east of mile post 16 from Montreal.

604–B In side (or east) wall of Roman Catholic church at St. Bazile, 7 feet 8 inches below sill of first window from front of building.

605–B In south end of west face of stone retaining wall behind east abutment of open culvert under Grand Trunk railway, 1 mile east of St. Bazile and at mileage 18·25 from Montreal.

606–B In south end of west face—14 inches below top—of concrete retaining wall behind east abutment of Grand Trunk railway bridge over Richelieu river, immediately east of Beloeil.

607–B In water-table course of stonework, in west wall—5 feet from northwest corner—of Grand Trunk station house at St. Hilaire.

608–B In east end of north face—20 inches below coping—of square concrete culvert under Grand Trunk railway, at the east line of a highway crossing, 2¼ miles east of St. Hilaire East and at mileage 25·15 from Montreal.

609–B In north end of east face of concrete retaining wall behind west abutment—18 inches above bridge seat—of plate-girder bridge on Grand Trunk railway, ½ mile west of Ste. Madeleine.

610–B In east face—2 feet below top—of north face wall of square concrete culvert under Grand Trunk railway, at a diagonal highway crossing, 2½ miles west of St. Hyacinthe and at mileage 33·2 from Montreal.

611–B In second course of stonework below brickwork, in west end of front (or north) wall of Grand Trunk station house at St. Hyacinthe.

612–B In fourth course of stonework below brickwork, in south end of front (or east) wall of St. Hyacinthe registry office, on west side of du Palais street.

613–B In first course of stonework above concrete sidewalk, in north wall of clock tower of St. Hyacinthe post office, immediately west of main doorway.

614–B In east face-wall of concrete tile culvert under Canadian Pacific railway immediately south of diamond crossing of Grand Trunk railway at Ste. Rosalie Junction.

624–B In side of concrete bench-mark pier, 23 feet south of north line of Grand Trunk railway right of way, 2 miles east of Ste. Rosalie Junction, 80 feet west of a rail-stand and 1,820 feet west of mile post 40 from Montreal.

625–B In second course of stonework below bridge seat, in north end of west face of east abutment of plate-girder bridge on Grand Trunk railway, 700 feet west of Britannia Mills station.

626–B In second course of stonework below brickwork, in front (or southwest) wall of registry office at St. Liboire, 11 feet 3 inches from west corner of building.

627–B In second course of stonework below top, in southwest face of southwest wing wall of Grand Trunk railway bridge over Black river at Upton.

628–B In water-table course of stonework, in south end of side (or west) wall of Roman Catholic church at Upton.

629–B In second course of stonework below seat of I-beams, in northeast face of northeast wing wall of open culvert under Grand Trunk railway, 2¾ miles west of Actonvale and at mileage 51·6 from Montreal.

630–B In first course of stonework below water-table course, in east end of south wall of clock tower of Actonvale post office.

631–B In top course of stonework, in north face of northeast wing wall of stone arch culvert under Grand Trunk railway, 2 miles east of Actonvale and at mileage 56·3 from Montreal.

632–B In first course of stonework above bridge seat, in north end of west face of retaining wall behind east abutment of plate-girder bridge over Moose river, 2¼ miles west of Danby and at mileage 59·8 from Montreal.

633–B In west face of coping on south end of small stone culvert under Grand Trunk railway, ¼ mile east of Danby.

634–B In east end of north face of north concrete face-wall of pipe culvert under Grand Trunk railway, 1 mile west of South Durham and at mileage 65·2 from Montreal.

635–B In first course of stonework below cap-stone, in south face—immediately above southwest wing wall—of stone arch culvert under Grand Trunk railway, ⅓ mile east of South Durham.

636–B In third course of stonework below bridge seat, in south end of east face of west abutment of plate-girder bridge on Grand Trunk railway, ⅓ mile east of Lisgar.

637–B In east face of coping on south end of small stone culvert under Grand Trunk railway, ¼ mile east of Gore.

638–B In second course of stonework above bridge seat, in north end of east face of retaining wall behind west abutment of Grand Trunk railway bridge over St. Francis river, 1⅓ miles northwest of Richmond.

639–B In west wall (facing main line) of Grand Trunk station house at Richmond. The bench-mark is in concrete foundation of dining room bay window.

640–B In sixth course of stonework below brickwork, in west end of south wall of Richmond post office.

641–B In third course of stonework below seat of I-beams, in west face of south abutment of open culvert under Grand Trunk railway, 2¼ miles south of Richmond and at mileage 78·7 from Montreal.

642–B In east side of long curved rock cut on Grand Trunk railway—near south end of cut—330 feet north of an old stone culvert, 800 feet north of north switch of Morse passing-track and at mileage 81·4 from Montreal.

643–B In first course of stonework below bridge seat, in west face of north abutment of plate-girder bridge on Grand Trunk railway, 2½ miles north of Windsor Mills and at mileage 84·1 from Montreal.

644–B In first course below brickwork, in west face of corner stone at northwest corner of a brick business block in the town of Windsor Mills, at the southeast corner of Richmond and St. George streets.

645–B In third course of stonework above bridge seat, in west end of north face of retaining wall behind south abutment of plate girder bridge over Wattapikaw river, ¼ mile south of Windsor Mills station.

646–B In top course of stonework, in west end of south face of retaining wall behind north abutment of small plate girder bridge on Grand Trunk railway, 0·4 mile north of Titus flag-station and at mileage 89·9 from Montreal.

647–B In second course of stonework below top, in north end of west face of northwest retaining wall of Grand Trunk railway bridge over St. Francis river, 1½ miles north of Bromptonville.

648–B In second course of stonework below water-table course, in north end of east wall of vestry (at northeast corner) of Roman Catholic church, Bromptonville.

649–B In west end of north face of concrete retaining wall behind south abutment of plate-girder bridge on Grand Trunk railway, 2 miles south of Bromptonville and at mileage 96·6 from Montreal.

650–B In side of concrete bench-mark pier, 10 feet east of west line of Grand Trunk railway right of way, 2,000 feet north of a stone arch culvert and 575 feet south of mile post 99 from Montreal—about 2 miles north of Sherbrooke.

3 In second course of stonework below top, in west end of south face of retaining wall behind north abutment of Grand Trunk railway bridge over Magog river at Sherbrooke, 2,000 feet north of the station.

BENCH-MARKS BETWEEN STE. ROSALIE JUNCTION AND FARNHAM, QUE., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 33.

615-B In concrete foundation of Canadian Pacific water-tank at St. Hyacinthe. The bench-mark is 1 foot below woodwork, in the side which faces the track.

616–B In west face-wall of concrete tile culvert under Canadian Pacific railway, 2½ miles south of St. Hyacinthe and at mileage 22·2 from Farnham.

617–B In north end of west face of west concrete face-wall of tile culvert under Canadian Pacific railway, at mileage 19·2 from Farnham.

618–B In east face—10 inches below top—of concrete retaining wall behind north abutment of Canadian Pacific railway bridge over Black river, ¼ mile south of St. Pie.

619–B In west face-wall of concrete tile culvert under Canadian Pacific railway at mileage 13·7 from Farnham.

620–B In east face—1 foot below top—of concrete footing of semaphore beside Canadian Pacific railway track, at second telegraph pole north of mile post 11 from Farnham. This is the second (or distant) semaphore south of diamond crossing of Montreal and Southern Counties (electric) railway at Abbottsford.

621–B In east face-wall of concrete tile culvert under Canadian Pacific railway, 2 miles north of Canrobert and at mileage 7·5 from Farnham.

622–B In south end of east face of east concrete face-wall of tile culvert under Canadian Pacific railway, 500 feet south of Canrobert station.

623–B In side of concrete bench-mark pier, 6 feet east of west line of Canadian Pacific railway right of way, 250 feet south of a whistle post for north bound trains and 630 feet south of a culvert at mileage 1·4 north of Farnham.

62 In top course of stonework, in east end of front (or south) wall of Canadian Pacific station house at Farnham.

BENCH-MARKS BETWEEN CHAUDIERE AND RICHMOND, QUE., VIA GRAND TRUNK RAILWAY.

Elevations on page 34.

651–B In side of concrete bench-mark pier, 7 feet west of east line of Grand Trunk railway right of way, 2¼ miles south of Chaudière, 560 feet south of culvert at mileage 161·5, and 500 feet north of culvert at mileage 161·3 from Montreal.

652–B In north face of rock exposure, 8 feet east of west line of Grand Trunk railway right of way, 680 feet north of a stone culvert, ½ mile south of Craig Road and 570 feet north of mile post 157 from Montreal.

653–B In second course of stonework below bridge seat, in west end of south face of north abutment of plate-girder bridge on Grand Trunk railway, ¾ mile north of St. Agapit and at second telegraph pole south of mile post 153 from Montreal.

654–B In west end of north face of south concrete abutment of small culvert under Grand Trunk railway, 1,300 feet south of overhead (highway) bridge at St. Agapit.

655–B In water-table course of stonework, in side (or south) wall of Roman Catholic church at St. Agpit 3 feet from rear of main section of building.

656–B In east face of flat gray boulder—7 feet by 7 feet—lying exactly on west line of Grand Trunk railway right of way, 3 miles north of Dosquet and 1,630 feet south of mile post 147 from Montreal.

657–B In first course of stonework below bridge-seat, in west end of north face of south abutment of plate-girder bridge on Grand Trunk railway, ½ mile south of Dosquet.

658–B In second course of stonework below cap-stone, in north face of southwest retaining wall of plate-grider bridge on Grand Trunk railway, 3½ miles south of Dosquet and at mileage 140·3 from Montreal.

659–B In north face of large rounded boulder, 20 feet west of east line of Grand Trunk railway right of way, 1⅓ miles north of Lyster and at mileage 137·3 from Montreal.

660–B In west end of north face of concrete retaining wall behind south abutment—4 feet 9 inches above bridge seat—of Grand Trunk railway bridge over Bécancour river at Lyster.

661–B In west face of exposed rock surface, 3 feet west of east line of Grand Trunk railway right of way, 20 feet south of a concrete tile culvert, 700 feet south of a diagonal highway crossing and between second and third telegraph poles south of mile post 133 from Montreal.

662–B In-top course of stonework, in west face of northwest wing wall of stone arch culvert under Grand Trunk railway, 1,100 feet south of Ste. Julie station.

663–B In west face of exposed rock surface, 10 feet west of east line of Grand Trunk railway right of way 400 feet south of mile post 128 from Montreal and between fourteenth and fifteenth telegraph poles north of a highway crossing.

664–B In second course of stonework above bridge seat, in west end of north face of retaining wall behind south abutment of plate-girder bridge on Grand Trunk railway, 2½ miles north of Plessisville and at mileage 125·7 from Montreal.

665–B In east end of north face of concrete retaining wall behind south abutment—18 inches above bridge seat—of plate-girder bridge on Grand Trunk railway, ¼ mile south of Plessisville.

666–B In first course of stonework below water-table course, in west wall of Plessisville Roman Catholic Roman church, 3 feet 6 inches from front (or north) wall of building.

667–B In side of concrete bench-mark pier, 6 feet east of west line of Grand Trunk railway right of way, 100 feet north of a small culvert, 1¾ miles north of Princeville and 400 feet north of mile post 119 from Montreal.

668–B In third course of stonework below water-table course, in rear (or south) wall of Princeville Roman Catholic church, 9 feet east of centre line of building.

669–B In fourth course of stonework below top, in west face of retaining wall behind north abutment of plate-girder bridge on Grand Trunk railway, 3 miles south of Princeville and at mileage 114·3 from Montreal.

670–B In second course of stonework below brickwork, in north end of west wall (facing Grand Trunk station) of Victoriaville post office.

671–B In third course of stonework below water-table course, in side (or south) wall of Victoriaville Roman Catholic church, in second stone west of first basement window from front of building.

672–B In fourth course of stonework below top, in west face of retaining wall behind south abutment of Grand Trunk railway bridge over Nicolet river, ½ mile south of Victoriaville station.

673–B In north end of west face—21 inches below top—of square concrete culvert under Grand Trunk railway, 3 miles north of Warwick and at mileage 103·3 from Montreal.

674–B In first course of stonework above concrete walk, in west end of south wall of south transept of Warwick Roman Catholic church.

675–B In first course of stonework above bridge seat, in west end of north face of retaining wall behind south abutment of truss bridge on Grand Trunk railway, ¾ mile south of Warwick.

676–B In second altar-step below top, in southeast face of southeast wing wall of small plate girder bridge on Grand Trunk railway, 3 miles north of Kingsey and at mileage 95·4 from Montreal.

677–B In north end of west face—15 inches below top—of west concrete face-wall of pipe culvert under Grand Trunk railway, ⅓ mile north of Kingsey and at sixth telegraph pole south of mile post 93 from Montreal.

678–B In third course of stonework above bridge seat, in east end of north face of retaining all behind south abutment of Grand Trunk railway bridge over southwest branch of Nicolet river, 1½ miles north of Danville and at mileage 89·9 from Montreal.

679–B In first course of stonework below coping, in north end of east face of stone arch culvert under Grand Trunk railway, 1,000 feet south of Danville station.

680–B In first course of stonework below cap-stone, in east face of south abutment of open culvert under Grand Trunk railway, 2¾ miles south of Danville and at mileage 85·6 from Moutreal. This is the farther south of two culverts about 700 feet apart.

681–B In first course of stonework below seat of I-beams, in southwest face of northwest wing wall of open culvert under Grand Trunk railway, 700 feet south of St. Cyr station.

682–B In second course of stonework below top, in west end of south face of north abutment of stone and concrete culvert under Grand Trunk railway, 3½ miles northeast of Richmond and 90 feet north of mile post 80 from Montreal.

683–B In side of concrete bench-mark pier, 5 feet north of south line of Grand Trunk railway right of way, 330 feet east of mile post 78 from Montreal and 65 feet east of a whistle-post for trains bound toward Levis—about 1½ miles east of Richmond.

639–B In Grand Trunk station-house at Richmond—see line from Rouse Point to Sherbrooke.

BENCH-MARKS ON LOOP LINE AROUND CITY OF MONTREAL

Elevations on page 35.

Note.—For description of route followed in running this line see introduction.

DLXXXVI In first course of stonework above bridge seat, in north end of east face of retaining wall behind west abutment of Victoria avenue subway under Grand Trunk railway, immediately east of St. Lambert station.

DLXXXV In south face of stone wall separating Grand Trunk railway track from public roadway, at St. Lambert end of Victoria bridge over St. Lawrence river. The bench-mark is at east end of wall, 9 inches above bridge floor and 5 feet east of most easterly steel arch carrying power wires.

DLXXXIV In south face of stone wall separating Grand Trunk railway track from electric railway track, at Point St. Charles end of Victoria bridge over St. Lawrence river. The bench-mark is 18 feet east of west end of wall and directly beneath second steel arch (carrying power wires) from west end of bridge.

DLXXXIII In second course of stonework above bridge seat, in west end of north face of retaining wall behind south abutment of Grand Trunk railway swing bridge over Lachine canal, between Point St. Charles and St. Henri.

DCCCXLVI In second course of stonework above sidewalk, in front (or south) wall of Ste. Cunégonde Roman Catholic church, 15 feet from southeast corner of building. This church is at the corner of St. James and Vinet streets, Montreal.

807 In ninth course of stonework below bridge seat, in south end of east face of west abutment of Atwater avenue subway under Canadian Pacific railway, 1 mile west of Windsor street station.

808 In north (or Osborne street) wall of Canadian Pacific railway's Windsor street station. The bench-mark is 27 inches above concrete sidewalk and 26 feet west of west line of Stanley street.

809 In first course of stonework below water-table course, in semicircular wall of westerly (or Cathedral street) transept of St. James Roman Catholic cathedral, Dominion Square. The bench-mark is 22 feet from west wall of vestibule of small entrance at north side of transept.

810 In front (or south) wall—15 inches below brickwork and 3 feet 6 inches from southeast corner—of Canadian Pacific station-house, Westmount.

811 In third course of stonework below top, in north face of east abutment of private subway under Canadian Pacific railway, 1 mile east of Montreal West station, and 1,800 feet east of mile post 4 from Montreal—Windsor street.

812 In side (or north) foundation wall of Montreal West town hall, 2 feet below brickwork and 24 feet from front wall of building.

813 In northwest face of northeast concrete retaining wall—17 feet below bridge seat—of railway subway under Montreal-Smiths Falls line of Canadian Pacific railway, $\frac{3}{4}$ mile west of Montreal West station.

814 In face of southeast retaining wall of square concrete culvert under Canadian Pacific railway 650 feet southwest of St. Luc Junction station—on cutoff from St. Luc Junction to Montreal-Smith's Falls line.

815 In fourth course of stonework below brickwork, in north end of front (or west) wall of Roman Catholic school at Côte-des-Neiges—100 yards south of Canadian Pacific railway.

816 In Canadian Northern railway subway under Canadian Pacific railway, $\frac{3}{4}$ mile east of Côte-des-Neiges and near northerly entrance of Mount Royal tunnel. The bench-mark is placed vertically in top of concrete coping of retaining wall, at north side of Canadian Pacific railway, and at west side of Canadian Northern railway, 1 foot from sloping face of retaining wall.

817 In side (or west) concrete foundation wall of Canadian Northern railway electric power substation near northerly entrance of Mount Royal tunnel. The bench-mark is 21 inches below brickwork and 13 feet from front wall of building.

818 In west face of concrete retaining wall at east side of Park avenue subway under Canadian Pacific railway, $\frac{1}{2}$ mile west of Mile End station. The bench-mark is 26 inches above sidewalk through subway, in pilaster between fifth and sixth panels north of railway tracks.

819 In rear (or south) wall of Canadian Pacific station-house, Mile End. The bench-mark is 26 inches above concrete platform and 3 feet west of east line of St. Dominique street.

820 In fourth course of stonework below water-table course, in St. Urbain street wall of St. George's Roman Catholic church, 32 feet north of north wall of tower. This church is on Bernard avenue, between Waverley and St. Urban streets.

821 In east face of concrete retaining wall on top of north end of east abutment of Iberville street subway under Canadian Pacific railway, $1\frac{3}{4}$ miles southeast of Mile End station. The bench-mark is 20 inches below top of retaining wall and opposite east end of northerly girder.

822 In south end of east face of west concrete abutment—11 feet below bridge seat—of Moreau street subway under Longue Pointe branch of the Canadian Pacific railway. This subway is immediately north of Forsyth street and about 500 feet east of main track from Mile End to Place Viger station.

823 In south face of concrete retaining wall at north side of Canadian Pacific railway track in front of Belle Rive park, 400 feet west of subway leading to Longueuil ferry landing. The bench-mark is 6 feet west of east end of wall and 6 feet, 6 inches below top.

824 In easterly concrete abutment of Notre Dame street bridge over Canadian Pacific railway at entrance to Place Viger station yard. The bench-mark is 2 feet above track level, in east face of fourth buttress from east end of retaining wall at south side of street.

N In south end of west (or Callières street) wall of Montreal custom house—at the corner of Callières and Commissioner streets. The bench-mark is 4 feet 9 inches above concrete sidewalk.

825 In first course of stonework above basement windows, in west (or McGill street) wall of Customs examining warehouse, 21 feet from southwest corner of building.

BENCH-MARKS BETWEEN BRANTFORD AND LUCAN CROSSING, ONT., VIA GRAND TRUNK RAILWAY THROUGH GUELPH AND STRATFORD.

Elevations on page 36.

77-F In side of concrete bench-mark pier, 5 feet west of east line of Grand Trunk railway right of way, 1,470 feet north of a (private) subway and ½ mile north of Harrisburg.

78-F In south end of east face of stone coping on southeast retaining wall of deck-truss bridge on Grand Trunk railway, 2½ miles north of Harrisburg.

79-F In south end of east face of coping on east end of stone-arch subway under Grand Trunk railway, 1¾ miles south of Branchton.

80-F In south end of west face of coping on west end of stone-arch subway (farm road) under Grand Trunk railway, 2¾ miles south of Galt and at mile post 9 from Harrisburg.

81-F In second course of stonework above concrete platform, in front (or east) wall of Grand Trunk station-house at Galt, 22 feet from southeast corner of building.

82-F In first course of stonework above concrete sidewalk, in front (or east) wall of Galt post office, 26 feet south of north wall of clock tower and immediately north of a steel rain-water pipe.

82-F-2 In tenth course of stonework below bridge seat, in west face—fourth stone from south end—of east abutment of bridge by which Canadian Pacific railway passes over Grand Trunk railway, 1¼ miles north of Galt (Grand Trunk station).

83-F In first course of stonework above concrete sidewalk, in front (or east) wall of Preston post office, immediately south of northerly entrance.

84-F In seventh course of stonework below window sills, in south end of front (or west) wall of Preston town hall and fire station.

85-F Destroyed.

86-F In front (or west) wall of Hespeler town hall, 3 feet 6 inches below water-table course of stonework and between the two basement windows to the north of the main entrance.

87-F In top course of stonework, in east face of south abutment of large stone and concrete culvert under Grand Trunk railway, 3¼ miles north of Hespeler and at mileage 22·5 from Harrisburg.

88-F In side of concrete bench-mark pier, 9 feet east of west line of Grand Trunk railway right of way, ¾ mile south of Guelph Junction and 60 feet north of mile post 26 from Harrisburg.

89-F In Corinthian Stone Company's building, immediately northwest of Grand Trunk railway diamond crossing at Guelph Junction. The bench-mark is 18 inches above ground and 3 feet from east corner of building, in southeast wall (wall facing towards diamond).

90-F In fifth course of stonework below brickwork, in front (or south) wall of Grand Trunk station-house at Guelph, immediately west of west wall of ticket office.

91-F In first course of stonework below water-table course, in front (or east) wall of armoury at Guelph—directly above first basement window north of main entrance.

92-F In second course of stonework below water-table course, in small rounded wall (facing Douglas street) at east side of Guelph post office. The bench-mark is 6 feet from east wall of vestibule at entrance to Customs and Inland Revenue offices.

93-F In top course of stonework, in west face of retaining wall behind east abutment of subway under Grand Trunk railway, 2¼ miles east of Breslau and at mileage 55·8 from Toronto. The bench-mark is 14 feet north of centre line of track.

94-F In third course of stonework below top, in north face—2 feet from west end—of southeast retaining wall of Grand Trunk railway bridge over Grand river, ½ mile west of Breslau.

5–F In third course of stonework below brickwork, in front (or north) wall of Grand Trunk station-house at Kitchener, 33 feet from northeast corner of building.

96–F In fourth course of stonework below brickwork, in north (or Weber street) wall of Kitchener public library, 26 feet from northeast corner of building.

97–F In second course of stonework above concrete sidewalk, in north wall of Kitchener post office—corner of Benton street and King street east. The bench-mark is in line with west side of clock tower.

98–F In stone plinth-course of front (or south) wall of Grand Trunk station-house at Waterloo, 14 feet from southeast corner of building.

99–F In east (or King street) wall of Waterloo post office, 4 feet below water-table and 11 feet north of north wall of clock tower.

100–F In third course below coping, in northeast face of northwest retaining wall of small stone arch culvert under Grand Trunk railway, 3 miles east of Petersburg and 1,800 feet east of mile post 66 from Toronto.

101–F In east face of stone coping on north end of brick arch culvert under Grand Trunk railway, 1 mile east of Baden and 100 feet west of a highway crossing.

102–F In second course of stonework below water-table course, in front (or north) wall of New Hamburg public library, 8 feet from northwest corner of building.

103–F In west face of concrete coping on southwest brick retaining wall of Grand Trunk railway bridge over Nith river, $\frac{1}{2}$ mile west of New Hamburg.

104–F In third course below coping, in west end of south face of square stone culvert under Grand Trunk railway, 2 miles east of Shakespeare and at mileage 79·6 from Toronto.

105–F In side of concrete bench-mark pier, 7 feet north of south line of Grand Trunk railway right of way, $3\frac{1}{4}$ miles east of Stratford, 450 feet east of a highway crossing and 583 feet east of mile post 85 from Toronto.

106–F In first course of stonework above concrete platform, in front (or south) wall of Grand Trunk station-house at Stratford, 27 feet west of west wall of ticket office.

107–F In stone plinth-course of westerly wall of Stratford city hall, 21 feet north of centre line of Wellington street entrance.

108–F In second course of stonework below coping, in east face of southeast retaining wall of small plate-girder bridge on Grand Trunk railway, $\frac{3}{4}$ mile west of Stratford station.

109–F In south end of west face—2 feet 10 inches below top—of concrete retaining wall behind east stone abutment of plate-girder bridge on Grand Trunk railway, $2\frac{1}{2}$ miles west of St. Pauls and at mileage 95·8 from Toronto.

110–F In stone plinth-course of front (or east) wall of Grand Trunk station-house at St. Marys, 16 feet north of north wall of ticket office.

111–F In east face—10 inches below top—of southeast stone and concrete retaining wall of long plate-girder bridge over north branch of Thames river, on main line of Grand Trunk railway, 1 mile west of St. Marys Junction.

112–F In south face—6 inches below top—of stone and concrete retaining wall behind west abutment of plate-girder bridge over Fish creek, 2 miles east of Granton and at mileage 105·7 from Toronto.

113–F In east end of north face—9 inches below top—of large square concrete culvert under Grand Trunk railway, $1\frac{3}{4}$ miles west of Granton and at mileage 109·45 from Toronto.

113–F–2 In side of concrete bench-mark pier, 8 feet north of south line of Grand Trunk railway right of way, 2 miles east of Lucan and at mileage 111·65 from Toronto—200 feet west of a whistle-post to the east of crossing of road allowance between concessions VI and VII, township of Biddulph.

114–F In the first course of stonework below coping, in east end of north face of square stone (double) culvert under Grand Trunk railway, $\frac{3}{4}$ mile east of Lucan and 140 feet west of mile post 113 from Toronto.

337 In third course of stonework above ground, in west face—11 feet from north end—of northeast wing wall of Grand Trunk railway subway at Lucan Crossing.

BENCH-MARKS BETWEEN GUELPH JUNCTION AND PALMERSTON, ONT., VIA GRAND TRUNK RAILWAY.

Elevations on page 37.

Note.—These descriptions are written with the assumption that the railway runs in a northwesterly direction from Guelph Junction to Palmerston, except between Elora and Fergus, where the direction is northeasterly.

115–F In northeast face—5 inches below top—on concrete block forming foundation for semaphore pulley, 8 feet northeast of centre line of Grand Trunk railway track and 16 feet northwest of first (or home) semaphore northwest of diamond crossing of Canadian Pacific railway, 2¾ miles northwest of Guelph Junction.

116–F In northeast (or inner) face—5 feet 6 inches from southeast end—of coping on southwest face-wall of large stone arch culvert under Grand Trunk railway, 4½ miles southeast of Elora and at mileage 35·8 from Harrisburg.

117–F In first course of stonework below water-table course, in east wall of Elora post office, 9 feet north of north wall of clock tower.

118–F In northeast face of stone coping on north retaining wall of Grand Trunk railway bridge over Grand river at mileage 42·1 from Harrisburg—between Elora and Fergus. (See note above regarding direction of railway at this point).

119–F In first course of stonework below water-table course, in south wall of Fergus post office, 8 feet west of west wall of clock tower.

120–F In west end of north face of square concrete culvert under Canadian Pacific railway, beside a public highway, 140 feet northeast of diamond crossing of Grand Trunk and Canadian Pacific railways at Fergus.

121–F In second course of stonework below top, in northeast end of southeast face of northwest abutment of deck-truss bridge on Grand Trunk railway, 2¾ miles southeast of Alma and at mileage 46·3 from Harrisburg.

122–F In side of concrete bench-mark pier, 15 feet southwest of northeast line of Grand Trunk railway right of way, 25 feet northwest of a farm crossing, 2¾ miles northwest of Alma and 800 feet southeast of mile post 52 from Harrisburg.

123–F In top course of stonework, in southwest end of northwest face of southeast abutment of deck-truss bridge over Conestoga river, ⅓ mile southeast of Drayton.

124–F In southwest end of northwest face—40 inches below top—of concrete retaining wall behind southeast abutment of plate-girder bridge on Grand Trunk railway, ½ mile northwest of Moorefield.

305 In second course of stonework above ground, in west face of pilaster at southwest corner of porch at entrance to public library at Palmerston.

BENCH-MARKS BETWEEN FERGUS AND MELVILLE, ONT., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 37.

Note.—These descriptions are written with the assumption that the railway runs in an easterly direction from Fergus to Cataract and thence northerly to Melville; beyond Melville the Toronto-Owen Sound line is assumed to lie east-west.

125–F In centre of south face of square concrete culvert under Canadian Pacific railway, ½ mile west of Spier flag-station and at mileage 20·9 from Cataract.

126–F In west end of south face—11 inches below top—of small concrete arch culvert under Canadian Pacific railway, 2 miles east of Belwood and at mileage 15·7 from Cataract.

127–F In centre of north face of square concrete culvert under Canadian Pacific railway, 1¼ miles east of Orton and at mileage 11·6 from Cataract.

128–F In east end of south face of square concrete (double) culvert under Canadian Pacific railway, ⅓ mile west of Hillsburgh and at mileage 8·6 from Cataract.

129–F In west end of south face—9 inches below top—of south face-wall of triangular concrete (double) culvert under Canadian Pacific railway, ¾ mile west of Erin and at mileage 5·3 from Cataract.

130–F In side of concrete bench-mark pier, 9 feet north of south line of Canadian Pacific railway right of way, ¾ mile west of Cataract and 60 feet east of intersection of railway track with east line of a public highway—the road allowance between concessions IV and V west, township of Caledon.

131–F In east face—5 inches below top—of concrete retaining wall behind south abutment of plate-girder bridge on Canadian Pacific railway, 0·4 mile north of Alton and at mileage 30·1 from Streetsville Junction.

132–F In north face—6 inches below top—of concrete retaining wall behind east abutment of plate-girder bridge over Credit river, ¼ mile west of Melville and at mileage 19·4 from Bolton.
NOTE.—This bridge replaces the trestle bridge containing bench-mark 266, on the Toronto-Owen Sound line. Bench-mark 266 has consequently been destroyed.

265 In southeast face of square concrete culvert running diagonally under Canadian Pacific railway—at a highway crossing—3½ miles east of Melville (or 1 mile west of Caledon) and at mileage 15·5 from Bolton.

BENCH-MARKS AT PORT DALHOUSIE AND PORT COLBORNE, ONT.

Elevations on page 38.

133–F In northeast bevelled corner—14 inches below top—of concrete retaining wall behind south abutment of plate-girder approach at south end of swing-bridge by which Welland branch of Grand Trunk railway crosses Welland canal, 1¾ miles south of Port Dalhousie.

134–F In first course of stonework above bridge seat, in north end of west face of retaining wall behind east abutment of swing (highway) bridge over Welland Canal at Port Dalhousie—immediately south of lock No. 1.

135–F In first course of stonework above concrete sidewalk, in south wall of Imperial Bank at Port Colborne, 16 feet from southwest corner of building.

136–F In top course of stonework, in circular stone foundation of municipal water-tower at Port Colborne. The bench-mark faces east.

137–F In east wall of Maple Leaf Milling company's flour mill at Port Colborne—a solid concrete building at west side of harbour. The bench-mark is 1 foot above concrete floor of wharf, in base of fifth pilaster south of doorway of dynamo room.

BENCH-MARKS BETWEEN FRANZ AND PORT ARTHUR, ONT., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 39.

709 In east face of large cube-shaped boulder, 50 feet north of Canadian Pacific railway track, 3 miles west of Franz and between sixteenth and seventeenth telegraph poles west of mile post 86 from Chapleau—immediately east of a small sand hill.

710 In south face of concrete retaining wall behind east abutment—3 feet 6 inches above bridge seat—of three-span plate-girder bridge over Magpie lake, 6¾ miles west of Franz and at mileage 90·1 from Chapleau.

711 In vertical rock exposure facing north, parallel to and 50 feet south of Canadian Pacific railway track, 2¼ miles east of Grasett and between second and third telegraph poles east of mile post 93 from Chapleau. The bench-mark is 10 feet west of a similar exposure facing west—at east side af a large swamp.

712 In north end of west face of concrete retaining wall behind east abutment—28 inches above bridge seat—of plate-girder bridge on Canadian Pacific railway, ⅔ mile west of Grasett and at mileage 95·85 from Chapleau.

713 In north face of large mass of rock, 80 feet south of Canadian Pacific railway track, 500 feet east of westerly switch of Ryerson passing-track and at mileage 99·6 from Chapleau.

714 In west face of vertical rock exposure, 40 feet north of Canadian Pacific railway track—at west end of a small rock cut—between third and fourth telegraph poles west of mile post 103 from Chapleau.

715 In south face of boulder, 55 feet north of Canadian Pacific railway track, 210 feet west of Tripoli west mile-board and 70 feet west of a stone-arch culvert at mile post 106 from Chapleau.

716 In south face of rock exposure—45 feet south of Canadian Pacific railway track and near rail level—2¾ miles east of Amyot and 25 feet west of first telegraph pole west of mile post 109 from Chapleau; this is opposite centre of a small borrow pit on north side of track.

717 In south face of vertical rock surface, 60 feet north of Canadian Pacific railway track—at south side of rocky hill facing Negwazu lake—¾ mile west of Amyot and at mileage 112·5 from Chapleau. The bench-mark is 350 feet west of point where shore line of lake diverges from direction of track at an angle of about 45°.

718 In west face of southwest retaining wall—10 inches below top—of square concrete culvert under Canadian Pacific railway, at mile post 115 from Chapleau.

719 In south end of east face of concrete retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at mileage 117·7 from Chapleau.

720 In east face of granite boulder—10 feet by 8 feet—190 feet north of Canadian Pacific railway track and at fifth telegraph pole east of mile post 121 from Chapleau. This boulder is 100 feet east of a large prominent mass of gray rock which is slightly farther from the track.

721 In third course of stonework below coping, in north face—6 feet from east end—of northeast retaining wall of combination stone-arch and plate-girder bridge on Canadian Pacific railway, 7¼ miles east of White River station and at mileage 124·6 from Chapleau.

722 In north end of west face of concrete retaining wall behind east abutment—4 feet 7 inches above bridge seat—of one-span plate-girder over White river, 2¾ miles east of White River station and at mileage 129·1 from Chapleau.

723 In north concrete wall of Canadian Pacific roundhouse at White River—1 foot below window sills—in north face of pilaster at northeast corner of rectangular concrete extension (containing three engine-stalls) on north side of main building.

723–A In front (or south) concrete foundation wall—4 feet below woodwork and 20 feet east of main entrance—of White River public school.

724 In north face of wedge-shaped boulder,50 feet south of centre line between tracks of Canadian Pacific railway and between second and third telegraph poles east of mile post 3 from White River.

725 In south face of large square boulder, 80 feet north of centre line between tracks of Canadian Pacific railway and at third telegraph pole west of mile post 6 from White River.

726 In north side of rock cut on Canadian Pacific railway, at sixth telegraph pole west of mile post 9 from White River.

727 In south face—9 inches below top—of concrete retaining wall behind west abutment of two-span plate-girder bridge over White river, at mileage 12·2 from White River.

728 In north end of west face of concrete retaining wall behind east abutment—30 inches above bridge seat—of two-span plate-girder bridge over Bremner river, at mileage 15·3 from White River.

729 In west face of south face-wall—5 inches below top—of square concrete culvert under Canadian Pacific railway, at mileage 19·1 from White River.

730 In south face of boulder on top of low sandy bank immediately north of Canadian Pacific railway track, at thirteenth telegraph pole west of mile post 21 from White River—40 feet east of easterly switch of a cross-over.

731 In first course of stonework below coping, in southeast face of southwest wing-wall of stone-arch culvert under Canadian Pacific railway, at mileage 23·4 from White River.

732 In south end of east face of concrete retaining wall behind west abutment—33 inches above bridge seat—of five -span plate-girder bridge over White river, at mileage 24·6 from White River.

733 In west end of south face of square concrete culvert under Canadian Pacific railway at mile post 28 from White River.

734 In east face of gray granite boulder, 65 feet south of Canadian Pacific railway track and between ninth and tenth telegraph poles west of mile post 31 from White River—behind the centre of a small clay and rock cut about 400 feet west of point where an arm of a lake touches south side of right of way.

735 In north end of west face of concrete retaining wall behind east abutment—28 inches above bridge seat—of plate-girder bridge over Cedar river, at mileage 33·9 from White River.

736 In south face of exposed rock surface, 45 feet north of Canadian Pacific railway track, 2½ miles east of Hemlo and at mile post 37 from White River—on top of west bank of an inlet which the railway has cut off from a small lake.

737 In southeast face of exposed rock surface, 50 feet north of Canadian Pacific railway track, ½ mile west of Hemlo and at fifth telegraph pole west of mile post 40 from White River—at east end of a small rock cut.

738 In top course of stonework, in southwest face of southwest retaining wall of stone-arch culvert under Canadian Pacific railway at mileage 42·6 from White River.

739 In east face of small white boulder, 30 feet north of Canadian Pacific railway track and 130 feet east of a concrete tile culvert at mileage 46·1 from White River.

740 In east face of stone coping on southeast retaining wall of steel truss and plate-girder bridge over Black river, at mileage 50·3 from White River.

741 In west end of south face of square concrete culvert under Canadian Pacific railway, 3¼ miles east of Heron Bay and at mile post 52 from White River.

742 In south face—34 inches below top and 11 inches from east end—of southwest concrete retaining wall of long steel bridge over Pic river, ¾ mile east of Heron Bay.

742–A In north face of exposed rock surface, 85 feet south of centre line between tracks of Canadian Pacific railway and 400 feet east of Heron Bay station.

743 In south side of small rock cut on sharp curve on Canadian Pacific railway—near west end of cut—2¾ miles west of Heron Bay and at second telegraph pole west of mile post 58 from White River.

744 In south face of exposed rock surface, 85 feet north of centre line between tracks of Canadian Pacific railway, 300 feet west of a whistle-post (for a large rock cut) for westbound trains and between tenth and eleventh telegraph poles west of mile post 61 from White River.

745 In south face of smooth clean-cut rock exposure in side of sand bank, 60 feet north of Canadian Pacific railway track, 0·4 mile west of Peninsula and 60 feet east of mile post 64 from White River.

746 In east face of vertical rock surface, 40 feet south of Canadian Pacific railway track, 230 feet west of westerly switch of Angler passing-track and at second telegraph pole west of mile post 67 from White River.

747 In south face of exposed rock surface, 45 feet north of Canadian Pacific railway track, 4¼ miles east of Coldwell and at second telegraph pole west of mile post 70 from White River.

748 In east face—8 inches below top—of concrete retaining wall at south side of Canadian Pacific railway track, 1¼ miles east of Coldwell, 170 feet west of a watchman's cabin and between first and second telegraph poles west of mile post 73 from White River.

749 In south face of large red boulder, 150 feet north of Canadian Pacific railway track, 1·6 miles west of Coldwell and 100 feet east of mile post 76 from White River.
NOTE.—Owing to the danger of this boulder being affected by frost, the elevation of this bench mark must be considered unreliable.

750 In vertical rock exposure facing south, 100 feet north of Canadian Pacific railway track, 265 feet east of Neys west mile-board, 370 feet east of a whistle-post for westbound trains and at mileage 78·9 from White River.

751 In south face of large boulder, 120 feet north of Canadian Pacific railway track, ¾ mile east of Middleton and at first telegraph pole east of mile post 82 from White River.

752 In south face of large broken mass of rock, 50 feet north of Canadian Pacific railway track, 440 feet east of a whistle-post for eastbound trains and at first telegraph pole east of mile post 85 from White River—at the base of a steep hill of rock through which the railway cuts.

753 In south face of outcrop of rock—20 feet north of Canadian Pacific railway track and 2 feet below rail level—485 feet east of a whistle-post for eastbound trains and 20 feet west of mile post 88 from White River.

754 In vertical rock exposure facing south, 30 feet south of Canadian Pacific railway track and between second and third telegraph poles west of mile post 91 from White River—behind east end of a short, deep, sharply curved rock cut.

755 In east end of north face of square concrete culvert under Canadian Pacific railway at mile post 94 from White River—between two large rock cuts.

756 In south face of exposed rock surface, 50 feet north of Canadian Pacific railway track, 2¼ miles east of Jackfish, 120 feet east of westerly switch of Santoy passing-track and between second and third telegraph poles west of mile post 97 from White River.

757 In north side of long rock cut on Canadian Pacific railway, 540 feet west of a whistle-post for westbound trains, ¾ mile west of Jackfish and at mileage 100·2 from White River.

758 In north face of exposed rock surface, 100 feet south of Canadian Pacific railway track, 3½ miles west of Jackfish and between first and second telegraph poles east of mile post 103 from White River—opposite a watchman's cabin situated at west end of a large rock cut.

759 In west face of exposed rock surface—at west end of a rock cut—40 feet north of Canadian Pacific railway track and at mileage 105·9 from White River.

760 In north end of west face of concrete retaining wall behind east abutment—2 feet above bridge seat—of steel truss bridge over Black river, at mileage 110·5 from White River.

761 In south face of boulder in side of gravelly bank, 75 feet north of Canadian Pacific railway track and at second telegraph pole east of mile post 114 from White River—within the limits of Bluejay passing-track.

762 In southeast face of vertical rock surface—slightly above rail level—at the base of a rocky hill about 75 feet north of Canadian Pacific railway track, 2 miles east of Schreiber and at mileage 116·4 from White River.

763 In south concrete wall of Canadian Pacific roundhouse at Schreiber—20 inches below window sills—in south face of pilaster at southeast corner of rectangular concrete extension (containing three engine-stalls) on south side of main building.

764 In west face of southeast retaining wall of concrete subway under Canadian Pacific railway at west end of Schreiber station grounds. The bench-mark is 2 feet above roadway and 3 feet, 8 inches from south end of retaining wall.

765 In east face of exposed rock surface—slightly below rail level—30 feet north of Canadian Pacific railway track and at second telegraph pole east of mile post 3 from Schreiber.

766 In north side of rock cut on Canadian Pacific railway 520 feet west of Horn west mile-board, 300 feet east of a rail-stand and 35 feet east of mile-post 6 from Schreiber.

767 In south face of vertical rock surface on east side of rocky hill, 80 feet north of centre line between tracks of Canadian Pacific railway and 70 feet west of mile post 10 from Schreiber. The bench-mark is opposite west end of a straight fill about 200 yards in length.

768 In southwest face of large flat outcrop or rock, 60 feet north of centre line between tracks of Canadian Pacific railway, 1¼ miles east of Rossport and between first and second telegraph poles west of mile post 13 from Schreiber.

769 In south side of rock cut on Canadian Pacific railway—near west end of cut and at rail level—1¾ miles west of Rossport and at fifth telegraph pole west of mile post 16 from Schreiber.

770 In south end of west face of concrete retaining wall behind east abutment—30 inches above bridge seat—of plate-girder bridge on Canadian Pacific railway (eastbound track only), 4½ miles west of Rossport and at mileage 18·86 from Schreiber.

771 In east end of north face—6 inches below top—of square concrete culvert under Canadian Pacific railway, at mile post 22 from Schreiber, within the limits of Pays Plat passing-track.

772 In vertical rock exposure facing east, 110 feet north of Canadian Pacific railway track, 500 feet west of a whistle-post for westbound trains and 100 feet east of mile post 25 from Schreiber.

773 In west end of north face of small square concrete culvert under Canadian Pacific railway at fifth telegraph pole east of mile post 28 from Schreiber.

774 In west face of boulder in side of gravelly bank, 30 feet north of centre line between tracks of Canadian Pacific railway and 190 feet east of mile post 31 from Schreiber.

775 In south end of west face of concrete retaining wall behind east abutment—29 inches above bridge seat—of plate-girder bridge on Canadian Pacific railway, ¾ mile west of Gravel and at mileage 33·6 from Schreiber.

776 In east end of north face of coping on north end of concrete arch culvert under Canadian Pacific railway, at second telegraph pole west of mile post 38 from Schreiber.

777 In north face of large flat outcrop of rock, 40 feet north of Canadian Pacific railway track, 115 feet east of Gurney west mile-board and 180 feet west of mile post 41 from Schreiber.

778 In south face of large flat outcrop of rock, 40 feet north of Canadian Pacific railway track—at the head of a short steep grade—between twelfth and thirteenth telegraph poles west of mile post 44 from Schreiber.

779 In south face—6 inches below top—of concrete retaining wall behind east abutment—of through-truss bridge over Jackpine river, ¼ mile east of Kama and at mileage 46·4 from Schreiber.

780 In south face of vertical bank of red rock—about 120 feet long and 15 feet high—30 feet north of Canadian Pacific railway track, 60 feet east of a whistle-post for westbound trains, 2 miles west of Kama and at mileage 48·7 from Schreiber.

781 In north end of west face of concrete retaining wall behind east abutment—20 inches above bridge seat—of small plate-girder bridge on Canadian Pacific railway at mileage 50·73 from Schreiber and at east end of Ozone passing-track.

782 In north end of west face of concrete retaining wall behind east abutment—29 inches above bridge seat—of plate-girder bridge on Canadian Pacific railway, 1¾ miles east of Fire Hill and at mileage 53·53 from Schreiber.

783 In east end of north face of square concrete culvert under Canadian Pacific railway, 1¼ miles west of Fire Hill and at mileage 56·5 from Schreiber.

784 In north side of long rock cut on Canadian Pacific railway—90 feet from east end of cut and at rail level—3¼ miles east of Nipigon and at second telegraph pole east of mile post 60 from Schreiber.

785 In second course of stonework above bridge seat, in east face of northwest retaining wall of Canadian Pacific railway bridge over Nipigon river and Canadian Northern railway, ¾ mile east of Nipigon.

786 In north end of west face of east abutment of square concrete culvert under Canadian Pacific railway, 1¾ miles west of Nipigon and at mileage 65·1 from Schreiber.

787 In north side of rock cut on Canadian Pacific railway—30 feet from east end of cut—240 feet east of a whistle-post for eastbound trains and at mileage 67·8 from Schreiber; this is opposite a point on Canadian Northern railway at fifth telegraph pole west of mile post 82 from Jellicoe.

788 In second course of stonework above bridge seat, in north end of west face of retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, at mileage 70·5 from Schreiber.

789 In south end of west face of concrete retaining wall behind east abutment—30 inches above bridge seat—of steel-truss and plate-girder bridge over Black Sturgeon river, 1½ miles east of Coglin and at mileage 73·9 from Schreiber.

790 In first course of stonework above bridge seat, in south end of west face of retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, 1 mile west of Coglin and at mileage 76·45 from Schreiber; this is opposite a point on Canadian Northern railway at first telegraph pole east of mile post 91 from Jellicoe.

791 In top course of stonework, in north face of west abutment of square culvert under Canadian Pacific railway, 300 feet east of Hurkett station and immediately west of a water tank.

792 In south end of west face of stone and concrete retaining wall behind east abutment—27 inches above bridge seat—of through-truss bridge over Wolf river, 2 miles east of Dorion and at mileage 83·16 from Schreiber.

793 In first course below coping, in west end of north face of square stone culvert under Canadian Pacific railway, ¾ mile west of Dorion and at second telegraph pole east of mile post 86 from Schreiber.

794 In first course below coping, in west end of south face of square stone culvert under Canadian Pacific railway, ¼ mile west of Ouimet and at mileage 89·15 from Schreiber.

795 In vertical rock exposure facing north, 35 feet south of Canadian Pacific railway track, 500 feet west of westerly switch of Bowker passing-track and at second telegraph pole east of mile post 93 from Schreiber.

796 In second course of stonework above bridge seat, in south end of east face of retaining wall behind west abutment of plate-girder bridge over Pearl river, immediately west of Pearl station.

797 In southwest face of boulder, 120 feet south of Canadian Pacific railway track, 700 feet west of a whistle-post for eastbound trains and at third telegraph pole east of mile post 99 from Schreiber.

798 In northwest face of small boulder embedded in ground, beside ditch at south side of Canadian Pacific railway track, 290 feet east of order-board at Loon station.

799 In second course of stonework above bridge seat, in south end of west face of retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, at mileage 105·9 from Schreiber.

800 In second course of stonework above bridge seat, in south end of east face of retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at east end of Beck passing-track and at mileage 107·9 from Schreiber.

801 In second course of stonework above bridge seat, in south end of east face of retaining wall behind west abutment of plate-girder bridge on Canadian Pacific railway, at mileage 110·6 from Schreiber.

802 In second course of stonework above bridge seat, in south end of west face of retaining wall behind east abutment of plate-girder bridge on Canadian Pacific railway, ¾ mile east of Mackenzie and at mileage 113·2 from Schreiber.

803 Destroyed.

804 In vertical rock exposure facing west, 60 feet north of Canadian Pacific railway track, 0·4 mile east of Navilus and 60 feet west of mile post 120 from Schreiber—at the east end of a rock cut.

805 Destroyed.

806 In south face—13 inches below top—Of southeast concrete retaining wall of Canadian Pacific railway bridge over Current river, 2 miles east of Port Arthur.

93-E In second course of stonework below brickwork, in north end of front (or west) wall of Canadian Northern station-house, Port Arthur.

BENCH-MARKS BETWEEN JASPER, ALTA. AND LOOS, B.C., VIA GRAND TRUNK PACIFIC RAILWAY.

Elevations on page 41.

105–H In side of concrete bench-mark pier, 49 feet north of Grand Trunk Pacific railway track, $2\frac{3}{4}$ miles west of Jasper and 110 feet east of mile post 1030 from Winnipeg—opposite a point on Canadian Northern railway between tenth and eleventh telegraph poles west of mile post 109 from Tollerton.

106–H In north side of rock cut on Grand Trunk Pacific railway—near rail level—$5\frac{3}{4}$ miles west of Jasper and 33 feet west of mile post 1033 from Winnipeg.

107–H In south end of east face of concrete retaining wall behind west abutment—4 feet 4 inches above bridge seat—of steel-truss bridge over Miette river, $\frac{1}{2}$ mile east of Geikie and at mileage 1035·2 from Winnipeg.

108–H In north side of rock cut on Grand Trunk Pacific railway—near centre of cut and slightly below rail level—460 feet west of bridge over Miette river and 65 feet east of fourth telegraph pole east of mile post 1039 from Winnipeg.

109–H In north side of rock cut on Grand Trunk Pacific railway—65 feet from west end of cut—$1\frac{1}{2}$ miles east of Alberta-British Columbia boundary and at mile post 1043 from Winnipeg.

110–H In north side of short deep rock cut on Grand Trunk Pacific railway—135 feet from east end of cut and 4 feet above rail level—1 mile west of Yellowhead and 10 feet west of first telegraph pole east of mile post 1046 from Winnipeg.

111–H In concrete foundation—6 inches below woodwork and directly beneath the spout—of Grand Trunk Pacific water tank at Lucerne.

112–H In north end of west face of concrete block on top of most easterly pier of plate-girder bridge on Canadian Northern railway, $2\frac{1}{4}$ miles west of Lucerne and opposite a point on Grand Trunk Pacific railway at mileage 1051·5 from Winnipeg. The bench-mark is 9 feet below rail level.

113–H In south end of east face of concrete retaining wall behind west abutment—14 inches above bridge seat—of Grand Trunk Pacific railway bridge over Grant brook, $\frac{3}{4}$ mile east of Grant Brook station and at mileage 1058·4 from Winnipeg.

114–H In north end of east face of concrete retaining wall behind west abutment—4 feet 6 inches above bridge seat—of Grand Trunk Pacific railway bridge over Moose river, 2 miles west of Grant Brook station and at mileage 1061·2 from Winnipeg.

115–H In north side of rock cut on Grand Trunk Pacific and Canadian Northern railways—100 feet from east end of cut and near rail level—110 feet east of Rainbow east (C.N.R.) mile board, 85 feet west of G.T.P. mile post 1064 from Winnipeg and between third and fourth telegraph poles east of C.N.R. mile post 15 from Lucerne.

116–H In side of concrete bench-mark pier, 45 feet north of Grand Trunk Pacific railway track, $2\frac{3}{4}$ miles west of Rainbow and 56 feet east of fifth telegraph pole east of mile post 1068 from Winnipeg —also between tenth and eleventh poles east of C.N.R. mile post 19 from Lucerne.

117–H In north face—7 feet below top and 11 feet 6 inches from east end—of northeast concrete retaining wall of Canadian Northern railway bridge over Fraser river, $1\frac{1}{2}$ miles east of Resplendent and at mileage 22·2 from Lucerne—opposite a point on Grand Trunk Pacific railway at mileage 1071·5 from Winnipeg.

118–H In south end of west face of concrete retaining wall behind east abutment—4 feet 6 inches above bridge seat—of Grand Trunk Pacific railway bridge over Fraser river, $\frac{1}{2}$ mile west of Resplendent and at mileage 1073·6 from Winnipeg.

119–H In south end of east face of concrete retaining wall behind west abutment—6 feet 5 inches above bridge seat—of plate-girder bridge on Grand Trunk Pacific railway, $1\frac{1}{4}$ miles east of Mount Robson station and at mile post 1078 from Winnipeg.

120–H In north face of large broken mass of rock, immediately south of Grand Trunk Pacific railway track at twelfth telegraph pole west of mile post 1082 from Winnipeg. This is directly behind a guide-post indicating mount Robson and is 140 feet east of east end of a lookout platform 3 miles west of Mount Robson station.

121–H In south side of rock cut on Grand Trunk Pacific railway—near centre of cut and at rail level—$\frac{3}{4}$ mile east of Swiftwater and at seventh telegraph pole east of mile post 1085 from Winnipeg.

122–H In east face—40 inches below top—of concrete retaining wall at north side of Grand Trunk Pacific railway track, 65 feet west of easterly whistle-post for Albreda and at mileage 1088·4 from Winnipeg.

123–H In south side of long rock cut on Grand Trunk Pacific railway, 2 miles west of Albreda and 20 feet east of mile post 1091 from Winnipeg—this mile post being the sixth pole west of a small tunnel. The bench-mark is also 52 feet east of east end of the farthest west of three concrete retaining walls at north side of track.

124–H In south end of west face of concrete retaining wall behind east abutment—6 feet above bridge seat —of three-span plate-girder bridge over McLennan river, 2½ miles east of Tête Jaune and at mileage 1093·7 from Winnipeg.

125–H In south end of west face of concrete retaining wall behind east abutment—4 feet 9 inches above bridge seat—of through-truss bridge on Grand Trunk Pacific railway, ½ mile east of Shere and at mileage 1100·7 from Winnipeg.

126–H In side of concrete bench-mark pier, 42 feet south of Grand Trunk Pacific railway track, 625 feet east of easterly switch of Croydon passing-track and between first and second telegraph poles west of mile post 1108 from Winnipeg.

127–H In northwest face—13 inches below top—of northeasterly concrete footing under Grand Trunk Pacific (steel) water-tank at Dunster.

128–H In side of concrete bench-mark pier, 33 feet north of Grand Trunk Pacific railway track, 2·4 miles east of Raush Valley and 16 feet west of mile post 1120 from Winnipeg.

129–H In south end of west face of concrete retaining wall behind east abutment—7 feet 4 inches above bridge seat—of long steel trestle bridge over Raushuswap river, 1½ miles west of Raush Valley and at mile post 1124 from Winnipeg.

130–H In south end of west face of concrete retaining wall behind east abutment—4 feet 3 inches above bridge seat—of through-truss bridge on Grand Trunk Pacific railway, 1 mile east of Eddy and at mile post 1127 from Winnipeg.

131–H In Grand Trunk Pacific roundhouse at McBride, in northwest concrete foundation wall (wall facing station)—10 inches below brickwork and 3 feet 7 inches from north corner—of one-room extension to main building.

132–H In south end of west face of concrete retaining wall behind east abutment—4 feet 6 inches above bridge seat—of through-truss bridge on Grand Trunk Pacific railway, 2½ miles west of McBride and at mileage 1137·2 from Winnipeg.

133–H In side of concrete bench-mark pier, 27 feet north of Grand Trunk Pacific railway track, 3,440 feet feet east of east end of a trestle bridge at mileage 1142·6 from Winnipeg and 16 feet west of second telegraph pole east of mile post 1142.

134–H In north side of small rock cut on Grand Trunk Pacific railway—60 feet from east end of cut—½ mile west of Legrand and between thirteenth and fourteenth telegraph poles west of mile post 1148 from Winnipeg.

135–H In north face of southeast concrete retaining wall of tunnel on Grand Trunk Pacific railway, 3½ miles east of Rider and at mileage 1152·8 from Winnipeg. The bench-mark is 10 inches above rail level and 64 feet east of head-wall at eastern portal of tunnel.

136–H In south side of rock cut on Grand Trunk Pacific railway—100 feet from west end of cut and 6 inches above rail level—935 feet east of easterly whistle-post for Rider and at mileage 1155·5 from Winnipeg.

137–H In south end of west face of concrete retaining wall behind east abutment—2 feet above bridge seat —of two-span truss bridge over Goat river, 2 miles east of Rooney and at mileage 1160·5 from Winnipeg.

138–H In southwest face—11 inches below top—of southwesterly concrete footing under Grand Trunk Pacific (steel) water-tank at Rooney.

139–H In top of concrete bench-mark pier, 45 feet south of Grand Trunk Pacific railway track, 1,480 feet west of west end of trestle bridge at mileage 1169·4 from Winnipeg and between seventh and eighth telegraph poles east of mile post 1170—1¼ miles east of Loos.

BENCH-MARKS BETWEEN ABBOTSFORD AND RESPLENDENT, B.C., VIA CANADIAN PACIFIC RAILWAY TO MATSQUI AND CANADIAN NORTHERN RAILWAY TO RESPLENDENT.

Elevations on page 42.

Note.—These descriptions are written with the assumption that the railway runs in a northerly direction from Abbotsford to Matsqui, thence easterly to Hope, thence northerly to Ashcroft, thence easterly to Kamloops Junction, thence northerly to Jackman and thence easterly to Resplendent.

28–J In east concrete foundation wall—6 inches below concrete blocks and 9 feet, 4 inches from south (or front) wall—of Glazeley's Block at Abbotsford, a concrete-block structure on the north side of the main street and on west side of first street west of Canadian Pacific railway.

29–J In north face of concrete base of pilaster at northeast corner of British Columbia Electric Railway company's Matsqui substation—in the village of Clayburn.

30–J In south concrete foundation wall—3 feet, 9 inches below woodwork and 2 feet from southeast corner—of signal tower at diamond crossing of Canadian Pacific and Canadian Northern railways near Matsqui.

31–J In west face of hill of rock through which is the first rock cut east of Matsqui on Canadian Northern railway. The bench-mark is 6 or 8 feet above and about 50 feet south of track, 1225 feet west of Sumas west mile-board and at mileage 84·45 from Boston Bar.

32–J In north face of exposed mass of smooth rock in side of steep clay bank cut away by Canadian Northern railway, 1350 feet east of mile post 80 from Boston Bar and 15 feet south of track.

33–J In south face of outcrop of rock, 8 feet north of north line of Canadian Northern railway right-of-way —at the base of a rocky hill just west of a curve in the railway—about mileage 75·75 from Boston Bar.

34–J In south concrete foundation wall—5 feet 6 inches from south-east corner—of municipal hall at Chilliwack, immediately north of Canadian Northern railway.

35–J In concrete foundation of side (or west) wall of Chilliwack post office, 10 feet from front wall of building and immediately below stonework.

36–J In south face of boulder partly buried in ditch, 14 feet north of south line of Canadian Northern railway right of way, 185 feet east of a highway crossing and 0·6 mile east of Rosedale.

37–J In south side of rock cut on Canadian Northern railway—1 foot above rail level and near centre of cut—330 feet east of a bridge over a stream and at mileage 58·7 from Boston Bar.

38–J In north face of exposed rock surface, 35 feet south of south line of Canadian Northern railway right of way and at south side of main road to Hope. The bench-mark is 860 feet east of point where this road crosses the railway and is at mileage 56·25 from Boston Bar.

39–J In south side of deep rock cut on Canadian Northern railway—70 feet from east end of cut—670 feet east of the crossing of a road leading to a cemetery, 790 feet east of Cheam View east mile-board and at mileage 52·8 from Boston Bar.

40–J In side of concrete bench-mark pier, 3 feet north of south line of Canadian Northern railway right of way, 30 feet west of a gate in the fence, 900 feet west of a bridge over a stream and between fourth and fifth telegraph poles west of mile post 47 from Boston Bar.

41–J In east face of boulder lying on south line of Canadian Northern railway right of way, immediately west of a small stream at mileage 45·6 from Boston Bar.

42–J In west face of exposed rock surface—6 feet above and 36 feet south of Canadian Northern railway track—at west entrance of a large rock cut (the first one east of a long trestle bridge), ¾ mile west of Hope.

43–J In north end of west face of concrete retaining wall behind east abutment—3 feet 8 inches above bridge seat—of Kettle Valley railway bridge over Fraser river at Hope.

Direction, Hope to Ashcroft—North.

44–J In west face of exposed rock surface, 37 feet east of Canadian Northern railway track, 2¼ miles north of Hope and between fourth and fifth telegraph poles north of mile post 38 from Boston Bar—directly behind concrete inflow of a timber culvert.

45–J In west face of mass of rock, 75 feet east of Canadian Northern railway track, 2,200 feet south of a bridge over a stream and between twelfth and thirteenth telegraph poles south of mile post 33 from Boston Bar—at south end of a steep shaley bank lying along east side of track. The bench-mark is marked by a white cross painted on a large fir tree growing beside the rock.

46–J In south face of vertical rock surface, 40 feet west of Canadian Northern railway track, 870 feet south of a bridge over a small stream and at mileage 29·5 from Boston Bar—at the south entrance of a small rock cut.

47–J In south face of mass of rock, 37 feet east of Canadian Northern railway track, 2 miles north of Yale and at mileage 24·8 from Boston Bar.

48–J In west face—7 inches below top and 18 inches from south end—of concrete retaining wall at west side of Canadian Northern railway track at mileage 21·5 from Boston Bar—at northerly portal of the " twin tunnels ".

49–J In south face of mass of rock, 13 feet west of Canadian Northern railway track and nearly at rail level, 5 feet north of northerly switch of Stout passing track and 180 feet north of mile post 18 from Boston Bar.

50–J In west face—4 feet below top and 7 feet from south end—of northwest concrete retaining wall of Canadian Northern railway bridge at mileage 16·7 from Boston Bar. This is a plate-girder bridge supported at the centre by a steel trestle tower.

51–J In south face of exposed rock surface, 53 feet east of Canadian Northern railway track and at rail level, 1,380 feet south of southerly switch of Chapman passing-track and between sixth and seventh telegraph poles south of mile post 13 from Boston Bar—at south end of a deep rock cut.

52–J In south face of large rounded mass of rock, 50 feet west of Canadian Northern railway track, 180 feet north of a rail-stand and 120 feet south of mile post 10 from Boston Bar.

53–J In east end of south face of concrete retaining wall behind north abutment of open culvert under Canadian Northern railway, at mileage 6·7 from Boston Bar and about ½ mile north of Hell Gate tunnel.

54–J In side of concrete bench-mark pier, 8 feet west of east line of Canadian Northern railway right of way, 60 feet south of an eight-foot jog in the right of way fence and 90 feet north of mile post 3 from Boston Bar.

55–J In west end of south face of concrete retaining wall behind north abutment—4 feet 6 inches above bridge seat—of long steel trestle bridge over Anderson river, 2 miles south of Boston Bar.

56–J In east end of south face of concrete retaining wall behind north abutment—6 feet 2 inches above bridge seat—of long steel trestle bridge on Canadian Northern railway, 2 miles north of Boston Bar and at mileage 123·7 from Kamloops Junction.

57–J In west end of south face of concrete retaining wall behind north abutment—4 feet 3 inches above bridge seat—of long steel trestle bridge on Canadian Northern railway, at mileage 120·1 from Kamloops Junction and at southern portal of first tunnel south of Boothroyd passing-track.

58–J In south face of small boulder, 7 feet east of east line of Canadian Northern railway right of way, 150 feet north of Inkitsaph flag-station and at mileage 114·8 from Kamloops Junction.

59–J In west face of large boulder partly buried in hillside, 3 feet below and 42 feet east of Canadian Northern railway track, ¾ mile south of Falls Creek station and 130 feet south of mile post 111 from Kamloops Junction—460 feet north of a flume carrying a stream under track.

60–J In west end of south face of concrete retaining wall behind north abutment—4 feet 8 inches above bridge seat—of one-span plate-girder bridge on Canadian Northern railway, at mileage 107·35 from Kamloops Junction.

61–J In east face—3 feet below top—of concrete retaining wall behind north abutment of long steel arch bridge over Fraser river and Canadian Pacific railway, 5¾ miles south of Lytton.

62–J In south face of concrete retaining wall behind south abutment of Canadian Northern railway bridge over Fraser river, ½ mile south of Lytton. The bench-mark is 22 inches below top of retaining wall and 11 feet 6 inches west of centre line of track.

63–J In east face—3 feet below top and 5 feet 4 inches from north face—of southeast concrete retaining wall of Canadian Northern railway bridge over Thompson river, ½ mile north of Lytton.

64–J In east face of rough pyramid-shaped mass of rock, 25 feet west of Canadian Northern railway track, ¼ mile north of a tunnel, 800 feet south of Gossett section house and between third and fourth telegraph poles south of mile post 91 from Kamloops Junction.

65–J In west face of large mass of rock, 55 feet east of centre line of Canadian Northern railway track and near mile post 88 from Kamloops Junction.

66–J In south face of steep hill of rock at southern portal of a tunnel, the farthest north of three tunnels which are within a short distance of one another. The bench-mark is 25 feet east of Canadian Northern railway track and 110 feet north of Skoonka south mile-board.

67–J In side of concrete bench-mark pier, 28 feet east of Canadian Northern railway track, 130 feet south of a road crossing, 700 feet south of a trestle bridge and ¾ mile south of Spence Bridge station.

68–J In south face—22 inches below top—of concrete tombstone projecting about 3 feet above ground, 50 feet east of Canadian Northern railway track, 350 feet north of order-board at Spence Bridge station and 670 feet north of highway bridge over Thompson river.

69–J In south face of large rounded boulder, 40 feet east of Canadian Northern railway track, 350 feet south of a wooden culvert, 3¼ miles north of Spence Bridge and at mileage 71·6 from Kamloop Junction.

70–J In east face of outcrop of rock at foot of mountain range, 8 feet west of west line of Canadian Northern railway right of way, 650 feet south of first tunnel north of Martel passing-track and 1,500 feet north of mile post 68 from Kamloops Junction.

71–J In south end of west face—22 inches below top—of southwest concrete retaining wall of Canadian Northern railway bridge over Thompson river, 1 mile south of Basque and at mileage 59·7 from Kamloops Junction.

72–J In centre of west face of west concrete face-wall of tile culvert under Canadian Pacific railway at twenty-third telegraph pole south of C.P.R. mile post 54 from Kamloops, opposite a point on Canadian Northern railway 400 feet south of mile post 57 from Kamloops Junction.

73–J In south face—2 feet below top and 2 feet from east end—of concrete retaining wall behind north abutment of Canadian Northern Railway bridge over Thompson river at mile post 55 from Kamloops Junction, at the southern portal of a long curved tunnel.

74–J In east face of large triangular boulder, 37 feet west of west line of Canadian Northern railway right of way, 1¼ miles south of Ashcroft and at seventh telegraph pole south of mile post 50 from Kamloops Junction.

Direction, Ashcroft to Kamloops Junction—East.

75–J In north face—22 inches below top and 7 feet, 2 inches from east end—of northeast concrete retaining wall of Canadian Northern railway bridge over Thompson river, 1½ miles east of Ashcroft and at mileage 47·3 from Kamloops Junction.

76–J In north end of west face—1 foot below top—of concrete retaining wall behind east abutment of of Canadian Northern railway bridge over Thompson river, 3 miles east of Ashcroft and at mileage 45·8 from Kamloops Junction.

77–J In east face of exposed rock surface, 50 feet south of Canadian Northern railway track, 1,200 feet east of easterly switch of McAbee passing-track and at mileage 40·4 from Kamloops Junction —immediately west of a short, deep rock cut.

78–J In east face—1 foot below top—of coping on north concrete abutment of two span steel highway bridge over Thompson river, 2¼ miles west of Walhachin.

79–J In west face of concrete retaining wall behind west abutment of Canadian Northern railway bridge over Thompson river, 1½ miles west of Walhachin and at mileage 34·1 from Kamloops Junction. The bench-mark is 20 inches below top of retaining wall and 12 feet, 9 inches north of centre line of track.

80–J In south end of east face of concrete retaining wall behind west abutment—4 feet, 6 inches above bridge seat—of Canadian Northern railway bridge over Thompson river, 3¼ miles west of Savona and at mileage 28·9 from Kamloops Junction.

81–J In side of concrete bench-mark pier, 3 feet south of north line of Canadian Northern railway right of way, 1,200 feet west of Savona station and 530 feet west of crossing of road leading to bridge over Thompson river.

82–J In south face of exposed rock surface, 29 feet north of Canadian Northern railway track and at rail level, 1,800 feet west of a small wooden culvert and 65 feet west of mile post 23 from Kamloops Junction.

83–J In west face of rock cliff, 100 feet south of Canadian Northern railway track and about 1 foot above rail level—at western portal of tunnel—150 feet east of easterly switch of Copper Creek passing-track.

84–J In east face of hill of rock, 31 feet south of the east end of a rock cut on Canadian Northern railway and 1,500 feet east of mile post 16 from Kamloops Junction.

85–J In west face of rock cliff—105 feet south of Canadian Northern railway track and about 4 feet below rail level—at western portal of 2,800-foot tunnel at mileage 10·5 from Kamloops Junction.

86–J In south face of rocky hill lying immediately north of a public road 250 feet north of Canadian Northern railway, at a point opposite tenth telegraph pole east of mile post 4 from Kamloops Junction.

87–J In east face of concrete coping on most easterly pier of Canadian Northern railway bridge over North Thompson river at Kamloops Junction. The bench-mark is 9 inches below top of coping and directly in line with southerly plate-girder.

Direction, Kamloops Junction to Jackman—North.

88–J In west face of exposed rock surface, 35 feet west of east line of Canadian Northern railway, 4½ miles north of Kamloops Junction, 460 feet north of mile post 135 from Blue river and 230 feet north of point where power line wires cross from east to west side of track.

89–J In northwest face of exposed rock surface on hillside, slightly above and 50 feet east of Canadian Northern railway track, 3 miles south of Vinsulla and 1,050 feet north of mile post 128 from Blue river—at north end of a deep rock and clay cut.

90–J In northeast face of large boulder partly buried in hillside, 800 feet east of east line of Canadian Northern railway right of way, 2¼ miles north of Vinsulla and at mileage 122·4 from Blue river. This boulder lies about 20 feet south of a fence which runs east from a point 100 yards east of the railway.

91–J In top of concrete bench-mark pier, 4 feet west of east line of Canadian Northern railway right of way, 2 miles south of McLure and 20 feet north of a private crossing at mileage 118·5 from Blue river.

92–J In east face of mass of rock, 12 feet west of Canadian Northern railway track and near centre of a sharp curve—facing a steep gravelly bank—between third and fourth telegraph poles south of mile post 113 from Blue river.

93–J In north face of exposed rock surface—18 feet east of Canadian Northern railway track and at the north end of a rock cut—2½ miles south of Louis Creek station and between fourth and fifth telegraph poles north of mile post 110 from Blue river.

94–J In west face of exposed rock surface—15 feet east of Canadian Northern railway track and at the south end of a deep clay cut—1¼ miles north of Louis Creek station and 140 feet north of mile post 106 from Blue river.

95–J In southwest face of large boulder, 25 feet east of east line of Canadian Northern railway right of way, 600 feet south of a private crossing, 1¼ miles north of Barrière and at sixth telegraph pole south of mile post 103 from Blue river.

96–J In west face of boulder, 15 feet east of Canadian Northern railway track, 1¾ miles south of Chinook Cove and between fourth and fifth telegraph poles north of mile post 100 from Blue river.

97–J In west face of boulder, 30 feet east of centre line of road lying parallel to and about 400 feet east of Canadian Northern railway, 2¼ miles north of Chinook Cove and opposite a point between fifth and sixth telegraph poles north of mile post 96 from Blue river.

98–J In southwest face of large boulder, 25 feet west of west line of Canadian Northern railway right of way and 80 feet north of second crossing (0·4 mile) north of Chu Chua.

99–J In west face of vertical rock cliff, 30 feet east of Canadian Northern railway track—on a sharp curve—1¼ miles south of Mount Olie station and at third telegraph pole south of mile post 87 from Blue river.

100–J In west face—50 feet from south end—of outcrop of rock occurring in east side of long curved rock and clay cut on Canadian Northern railway, 2¼ miles north of Mount Olie station and at mileage 83·5 from Blue river.

101–J In east side of rock cut on Canadian Northern railway—near centre of cut—2¼ miles north of boulder and between third and fourth telegraph poles south of mile post 80 from Blue river.

102–J In west face of outcrop of rock occurring in east side of short clay cut on Canadian Northern railway, 1,400 feet south of a whistle post for northbound trains, 2 miles south of Blackpool and between seventh and eight telegraph poles north of mile post 76 from Blue river.

103–J In west face of exposed rock surface on east side of Canadian Northern railway track—near centre of a long clay bank—at second telegraph pole south of mile post 72 from Bule river.

104–J In east side of rock cut on Canadian Northern railway—near centre of cut—at fourth telegraph pole north of mile post 69 from Blue river.

105–J Destroyed.

106–J In east face—8 inches below top—of concrete footing under Canadian Northern water-tank at Birch Island. The footing referred to is the southeasterly one of the four footings inside chamber beneath tank.

107–J In east face of exposed rock surface—47 feet west of Canadian Northern railway track and near rail level—365 feet north of two whistle posts (one for northbound and one for southbound trains), 3½ miles north of Birch Island and between sixth and seventh telegraph poles south of mile post 58 from Blue river.

108–J In east face of concrete pier (built originally for astronomical observations), 7 feet west of west line of Canadian Northern railway right of way, 55 feet south of a private crossing, 2½ miles south of Vavenby and at mileage 55·5 from Blue river.

109–J In west face of large boulder, 50 feet east of Canadian Northern railway track and directly beneath telegraph wires, 1 mile north of Vavenby and between second and third telegraph poles south of mile post 52 from Blue river.

110–J In west face of white boulder, 25 feet east of Canadian Northern railway track—immediately behind a rail stand on a sharp curve—1¾ miles south of Irvine and between first and second telegraph poles north of mile post 49 from Blue river.

111–J In concrete foundation—8 inches below woodwork and 2 feet to the left of the spout—of Canadian Northern water-tank at Irvine.

112–J In west face of exposed rock surface—15 feet east of Canadian Northern railway track and 1 foot above rail level—½ mile north of bridge over North Thompson river above Irvine and between eleventh and twelfth telegraph poles south of mile post 43 from Blue river.

113–J In north face of boulder, 20 feet west of Canadian Northern railway track, 105 feet north of a whistle post for northbound trains and at eighth telegraph pole north of mile post 40 from Blue river.

114–J In east side of rock cut on Canadian Northern railway—50 feet from north end of cut—¾ mile north of McMurphy and at mileage 36·6 from Blue river.

115–J In southwest face of boulder, 55 feet east of Canadian Northern railway track, 580 feet north of a whistle post for northbound trains and at mileage 32·7 from Blue river.

116–J Destroyed.

117–J In west side of rock cut on Canadian Northern railway—near centre of cut—2⅓ miles north of Avola and at mileage 22·45 from Blue river.

118–J In east face of vertical rock surface, 22 feet west of Canadian Northern railway main line track, 150 feet north of southerly switch of Cottonwood Flats passing-track and between first and second telegraph poles north of mile post 19 from Blue river.

119–J In west side of rock cut on Canadian Northern railway—100 feet from north end of cut and at rail level—885 feet south of a whistle post for northbound trains, 970 feet south of a whistle post for southbound trains and between fifth and sixth telegraph poles south of mile post 16 from Blue river.

120–J In north face—2 feet below top—of stone and concrete retaining wall at east side of Canadian Northern railway track at mileage 13·1 from Blue river—immediately north of first bridge above Messiter.

121–J In west side of rock cut on Canadian Northern railway—near centre of cut—3½ miles north of Messiter, 170 feet north of a rail-stand and 80 feet south of mile post 10 from Blue river.

122–J In west side of rock cut on Canadian Northern railway—near centre of cut—530 feet north of Wolfenden north mile board and 400 feet south of mile post 7 from Blue river.

123–J In south face of mass of rock on hillside, 45 feet west of Canadian Northern railway track at mile post 4 from Blue river.

124–J In west concrete foundation—6 inches below woodwork and directly beneath the spout—of Canadian Northern water-tank at Blue river.

125–J In west concrete foundation wall—9 inches below woodwork and 5 feet, 6 inches from northwest corner—of Canadian Northern roundhouse at Blue river.

126–J In east face of flat white boulder, 80 feet west of Canadian Northern railway track, 1½ miles north of Blue River station, 210 feet south of "Yard Limit" post and at tenth telegraph pole south of mile post 109 from Lucerne.

127–J In east face of exposed rock surface—30 feet west of Canadian Northern railway track and at rail level—at thirteenth telegraph pole south of mile post 104 from Lucerne.

128–J In east face of concrete retaining wall behind south abutment of Canadian Northern railway bridge over North Thompson river, ¾ mile south of Thunder River station and at mileage 101·4 from Lucerne. The bench-mark is 3 feet, 10 inches above bridge seat and 2 feet west of easterly girder.

129–J In west face of smooth gray rock exposure, immediately east of Canadian Northern railway track and 50 feet north of a cascade on east side of track, at mileage 97·5 from Lucerne.

130–J In east side of rock cut on Canadian Northern railway—at deepest point of cut—215 feet north of mile post 95 from Lucerne and at a point where railway grade touches bank of North Thompson river.

131–J In east side of rock cut on Canadian Northern railway—100 feet from north end of cut—at mileage 92·2 from Lucerne; this is the first rock cut (⅛ mile) north of Pyramid.

132–J In west face of flat boulder, 50 feet east of Canadian Northern railway track—at rail level—175 feet south of bridge at mileage 88·6 from Lucerne.

133–J In east side of rock cut on Canadian Northern railway—near north end of cut—380 feet south of a whistle-post for northbound trains, 1,100 feet south of Lempriere south mile-board and at mileage 85·8 from Lucerne.

134–J In east side of rock cut on Canadian Northern railway—near north end of cut—2 miles north of Lempriere and at eleventh telegraph pole north of mile post 83 from Lucerne.

135–J In east side of boulder, 35 feet west of Canadian Northern railway track—near north end of large gravelly cut—at fifth telegraph pole north of mile post 80 from Lucerne.

136–J In west face of exposed rock surface—30 feet east of Canadian Northern railway track and beside a small watercourse—at fourteenth telegraph pole north of mile post 78 from Lucerne.

137–J In south face of boulder, 45 feet east of Canadian Northern railway track, 2¼ miles south of Albreda and 80 feet south of mile post 72 from Lucerne.

138–J In west face—6 inches below top—of concrete foundation under centre Canadian Northern water-tank at Albreda.

139–J In south end of west face of coping on southwest concrete retaining wall of plate-girder bridge on Canadian Northern railway, 2 miles north of Albreda and at mileage 67·65 from Lucerne.

140–J In west side of rock cut on Canadian Northern railway—near rail level—230 feet north of mile post 65 from Lucerne.

141–J In west side of rock cut on Canadian Northern railway—near centre of cut—⅓ mile north of Canoe River station and between sixth and seventh telegraph poles south of mile post 61 from Lucerne.

142–J In east face of flat mass of rock about 20 feet square, 40 feet west of Canadian Northern railway track, 300 feet north of a deep rock cut and at mileage 58·5 from Lucerne—beside a sharp curve in the railway.

143–J In west face of large boulder embedded in hillside, 140 feet east of east line of Canadian Northern railway right of way, 1,660 feet south of Swift Creek station and 180 feet south of a whistle-post for southbound trains.

144–J In top of concrete bench-mark pier, 4 feet west of east line of Canadian Northern railway right of way, 410 feet south of first creek crossing (1½ mile) north of Swift Creek station and at mileage 49·5 from Lucerne.

145–J In west face of small rock exposure on east line of Canadian Northern railway right of way, 2¼ miles south of Jackman, 350 feet south of a rail stand and 155 feet north of mile post 46 from Lucerne.

Direction, Jackman to Resplendent—East.

146–J In north face (side nearest track)—8 inches below top—of concrete foundation under centre of Canadian Northern water-tank, ½ mile east of Jackman.

147–J In south side of long solid rock cut on Canadian Northern railway—near centre of cut—3¾ miles east of Jackman and 15 feet west of mile post 40 from Lucerne.

148–J In west face of exposed rock surface, 30 feet south of Canadian Northern railway track—at east side of a small gully from which a stream flows through a culvert—1¾ mile west of Morey and 35 feet west of eighth telegraph pole west of mile post 37 from Lucerne.

149–J In north face—1 foot below top and 3 feet from west end—of concrete retaining wall at north side of Canadian Northern railway track, 1½ miles east of Morey and at mile post 34 from Lucerne.

150–J In north face of boulder embedded in hillside, 30 feet south of Canadian Northern railway track and 20 feet west of eighth telegraph pole west of mile post 31 from Lucerne.

151–J In west face of flat boulder about 10 feet square, 85 feet south of Canadian Northern railway track, 280 feet west of Mount Robson east mile board and between fourth and fifth telegraph poles west of mile post 28 from Lucerne.

152–J In north face of large flat boulder, 120 feet south of Canadian Northern railway track, 1¾ mile west of Resplendent and at mileage 25·4 from Lucerne—exactly opposite a small timber culvert at east end of a curve.

153–J In top of concrete bench-mark pier, 82 feet north of centre line of Canadian Northern railway track, 60 feet south of centre line of Grand Trunk Pacific railway track and 225 feet east of east end of C.N.R. bridge over Fraser river situated 1½ mile east of Resplendent and at mileage 22·2 from Lucerne.

117–H In Canadian Northern railway bridge over Fraser river, 1½ mile east of Resplendent—see line from Jasper to Loos.

BENCH-MARKS BETWEEN REVELSTOKE AND KAMLOOPS, B.C., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 44.

315–C In west end of south face of south concrete face-wall of tile pipe culvert under Canadian Pacific railway at mileage 3·9 from Revelstoke.

316–C In north face of very large mass of rock, 40 feet south of centre line between tracks of Canadian Pacific railway, 200 feet west of Clanwilliam east mile-board and at mileage 7·1 from Revelstoke.

317–C In rear (or west) face of diverting wall—1 foot below top and 5 feet from south end of wall—at south side of square concrete culvert under Canadian Pacific railway, 140 feet west of Clanwilliam west mile-board and at mileage 9·8 from Revelstoke. This is ¼ mile west of the farthest west of three short tunnels.

318–C In east end of south face of square concrete culvert under Canadian Pacific railway, 2 miles east of Three Valley and at mileage 12·6 from Revelstoke.

319–C In northwest face of point of rock on south bank of Eagle river, ¾ mile west of Three Valley and 200 feet southeast of plate-girder bridge on Canadian Pacific railway at mileage 15·44 from Revelstoke.

320–C In east face of large mass of rock, 2 feet north of north line of Canadian Pacific railway right of way (westbound track), 800 feet west of mile post 18 from Revelstoke and 1,630 feet west of a bridge over Eagle river.

321–C In west face of easterly concrete pier of Canadian Pacific railway bridge (eastbound track) over Eagle river, at mileage 18·9 from Revelstoke. The bench-mark is 8 feet south of north face of pier and 47 feet 6 inches below rail level.

322–C In side of concrete bench-mark pier, 3 feet north of south line of Canadian Pacific railway right of way, 1¼ mile east of Taft and 133 feet west of mile post 23 from Revelstoke.

323–C In east face of west concrete abutment of plate-girder bridge over Crazy creek, 450 feet east of Taft station, The bench-mark is directly beneath centre line of westbound track.

324–C In east face—14 inches below top and 5 feet from north end—of west concrete abutment of Canadian Pacific railway bridge over Eagle river, 2 miles east of Craigellachie and at mileage 26·5 from Revelstoke.

325–C In north face of concrete base of monument built to commemorate driving of last spike in transcontinental line of Canadian Pacific railway; this is 800 feet west of Craigellachie station, at north side of track.

326–C In top course of stonework, in east face—9 feet 6 inches from south end—of west abutment of Canadian Pacific railway bridge over Eagle river, ½ mile west of Malakwa and at mile post 33 from Revelstoke.

327–C In centre of east face of coping on west concrete abutment of Canadian Pacific railway bridge over Eagle river, at mileage 37·25 from Revelstoke.

328–C In centre of east face—1 foot below stone coping—of west concrete abutment of Canadian Pacific railway bridge over Eagle river, ½ mile east of Solsqua flag-station and at mileage 40·6 from Revelstoke.

329–C In centre of east face of stone coping on west abutment of Canadian Pacific railway bridge over Eagle river, ¾ mile east of Sicamous and at mile post 44 from Revelstoke.

330–C In east face—8 inches below bridge seat and 15 inches from south end—of west concrete abutment of five-span plate-girder bridge over Sicamous narrows, ¼ mile east of Sicamous.

331–C In north face of north concrete face-wall of tile pipe culvert under Canadian Pacific railway, 3½ miles west of Sicamous and at mileage 48·2 from Revelstoke.

332–C In northwest face of point of rock on shore of Salmon Arm—about 15 feet above water surface—150 feet north of western portal of tunnel on Canadian Pacific railway at mileage 52·24 from Revelstoke. This is the first point of rock on shore (about ¼ mile) east of Mowitch flag-station.

333–C In east end of north face—7 inches below top—of large square concrete culvert under Canadian Pacific railway, ¼ mile east of Canoe flag-station and at mileage 57·2 from Revelstoke.

334–C In north face of exposed rock surface on hillside, 29 feet south of Canadian Pacific railway track, 300 feet east of a private crossing, 1¾ mile east of Salmon Arm and at ninth telegraph pole east of mile post 62 from Revelstoke.

335–C In west face of concrete foundation—5 inches below woodwork—of pilaster at northwest corner of Canadian Bank of Commerce at Salmon Arm.

336–C In centre of west face—1 foot below stone coping—of east concrete abutment of plate-girder bridge over Salmon river, 1½ mile west of Salmon Arm and at mile post 65 from Revelstoke.

337–C In north face of exposed rock surface, 10 feet south of south line of Canadian Pacific railway right of way, 1¾ mile east of Tappen and at fourth telegraph pole east of mile post 69 from Revelstoke—about 150 feet east of east end of a sharp curve around a rocky point facing Salmon Arm.

338–C In side of concrete bench-mark pier, 2 feet north of south line of Canadian Pacific railway right of way, 240 feet west of a highway crossing, 316 feet east of mile post 76 from Revelstoke and ¾ mile West of Carlin flag-station.

339–C In front (or south) concrete foundation wall—8 inches below woodwork and 6 feet from southeast corner—of Notch Hill public school, 350 feet west of railway station.

340–C In west face of east concrete abutment—3 feet 6 inches below bridge seat and near centre of abutment—of plate-girder bridge on Canadian Pacific railway, 5½ miles west of Notch Hill and at mileage 85·4 from Revelstoke.

341–C In east end of north face of north concrete face-wall of pipe culvert under Canadian Pacific railway at mileage 91·6 from Revelstoke—within the limits of Stormont passing-track.

342–C In centre of west face—6 inches below stone coping—of east concrete abutment of Canadian Pacific railway bridge over Chase creek, ¼ mile east of Chase station.

343–C In centre of north face of square concrete culvert under Canadian Pacific railway, 1¼ mile west of Shuswap and at mileage 96·9 from Revelstoke.

344–C In side of concrete bench-mark pier, 2 feet north of south line of Canadian Pacific railway right of way, 920 feet east of a square concrete culvert, 520 feet east of mile post 99 from Revelstoke and 3¼ miles west of Shuswap.

345–C In east end of south face—8 inches below top—of square concrete culvert under Canadian Pacific railway, 2 miles east of Pritchard and at mileage 102·75 from Revelstoke.

346–C In east end of north face—9 inches below top—of square concrete culvert under Canadian Pacific railway, 1·6 miles west of Pritchard and at mileage 106·4 from Revelstoke.

347–C In east end of south face—9 inches below top—of square concrete culvert under Canadian Pacific railway, 1 mile east of Duck and at mileage 110·65 from Revelstoke.

348–C In east end of north face—11 inches below top—of large concrete arch culvert under Canadian Pacific railway, ½ mile west of Duck and at mile post 112 from Revelstoke.

349–C In east end of south face—8 inches below top—of square concrete culvert under Canadian Pacific railway, 3¾ miles west of Duck and at mileage 115·4 from Revelstoke.

350–C In west face—16 inches below bridge seat and 12 feet from north end—of east concrete abutment of plate-girder bridge over Campbell creek, at mileage 117·4 from Revelstoke.

351–C In north face—9 inches below top—of square concrete culvert under Canadian Pacific railway, at mileage 122·5 from Revelstoke.

352–C In east end of north face—9 inches below top—of square concrete culvert under Canadian Pacific railway, 4 miles east of Kamloops and 200 feet east of mile post 125 from Revelstoke.

353–C In north wall of city of Kamloops power station—a concrete building immediately north of Canadian Pacific railway, about 1 mile east of Kamloops. The bench-mark is 4 inches above water-table, in north face of pilaster at northeast corner of building.

354–C In second course of stonework below brickwork, in front (or north) wall—5 feet from northwest corner—of Canadian Pacific station-house at Kamloops.

355–C In fifth course of stonework below water-table course, in east end of north wall of court house at Kamloops—corner of First avenue and Seymour street.

87–J In Canadian Northern railway bridge over North Thompson river at Kamloops Junction—see line from Abbotsford to Resplendent.

TABLE II

RESULTS OF PRECISE LEVELLING

ROUSE POINT, N.Y., TO SHERBROOKE, QUE.

Run by G. F. Dalton and H. P. Moulton

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark ⊕	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No. ⊕	Miles	Miles	Feet	Feet	Feet 107·950	No. ⊕
⊕	581–B	1·8	1·8	−·003	−·003	114·059	581–B
581–B	582–B	3·1	4·9	−·005	−·008	132·415	582–B
582–B	583–B	1·9	6·8	+·009	+0·001	143·824	583–B
583–B	584–B	2·0	8·8	−·015	−·014	175·437	584–B
584–B	585–B	2·3	11·1	·000	−·014	182·913	585–B
585–B	586–B	3·6	14·7	−·019	−·033	181·929	586–B
586–B	587–B	0·4	15·1	+·006	−·027	185·041	587–B
586–B	588–B	3·1	17·8	+·005	−·028	180·842	588–B
588–B	589–B	2·9	20·7	+·013	−·015	173·769	589–B
589–B	590–B	4·3	25·0	+·023	+·008	126·722	590–B
590–B	591–B	0·8	25·8	−·003	+·005	132·823	591–B
591–B	592–B	2·6	28·4	+·011	+·016	90·468	592–B
592–B	593–B	1·2	29·6	−·017	−·001	90·363	593–B
593–B	594–B	0·3	29·9	+·008	+·007	88·453	594–B
594–B	595–B	3·1	33·0	+·026	+·033	74·491	595–B
595–B	596–B	2·6	35·6	+·011	+·044	50·845	596–B
596–B	597–B	4·4	40·0	+·033	+·011	57·990	597–B
597–B	597–B–2	1·8	41·8	+·002	+·013	55·560	597–B–2
597–B–2	598–B	1·0	42·8	+·002	+·015	88·091	598–B
598–B	599–B	1·9	44·7	−·008	+·007	88·519	599–B
599–B	600–B	1·6	46·3	+·008	+·015	84·546	600–B
600–B	601–B	3·2	49·5	+·007	+·022	79·327	601–B
601–B	602–B	1·4	50·9	−·007	+·015	78·735	602–B
602–B	603–B	2·0	52·9	+·006	+·021	63·175	603–B
603–B	604–B	1·0	53·9	+·011	+·032	64·800	604–B
604–B	605–B	1·0	54·9	−·005	+·027	54·438	605–B
605–B	606–B	3·2	58·1	−·016	+·011	66·138	606–B
606–B	607–B	0·8	58·9	+·011	+·022	85·648	607–B
607–B	608–B	3·0	61·9	+·016	+·038	129·962	608–B
608–B	609–B	2·4	64·3	+·005	+·043	106·506	609–B
609–B	610–B	5·7	70·0	+·012	+·055	115·842	610–B
610–B	611–B	2·4	72·4	−·017	+·038	111·913	611–B
611–B	612–B	0·2	72·6	+·004	+·042	110·415	612–B
612–B	613–B	0·2	72·8	−·003	+·039	108·969	613–B
611–B	614–B	2·0	74·4	+·007	+·045	108·778	614–B
614–B	624–B	2·1	76·5	−·023	+·022	140·108	624–B
624–B	625–B	2·8	79·3	−·023	−·001	212·173	625–B
625–B	626–B	2·4	81·7	−·010	−·011	294·428	626–B
626–B	627–B	3·3	85·0	−·011	−·022	198·845	627–B
627–B	628–B	0·3	85·3	+·004	−·018	215·106	628–B
627–B	629–B	3·5	88·5	+·019	−·003	222·508	629–B
629–B	630–B	2·7	91·2	·000	−·003	310·008	630–B
630–B	631–B	2·0	93·2	−·004	−·007	326·556	631–B
631–B	632–B	3·5	96·7	+·017	+·010	355·235	632–B
632–B	633–B	2·5	99·2	+·022	+·032	430·000	633–B
633–B	634–B	3·0	102·2	+·001	+·033	595·694	634–B

⊕ United States bench-mark on Chapman Block, Rouse Point, N.Y.

RESULTS OF PRECISE LEVELLING

ROUSE POINT, N.Y., TO SHERBROOKE, QUE.

Run by G. F. Dalton and H. P. Moulton

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark ⊕	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
634–B	635–B	1·2	103·4	·000	+·033	603·014	635–B
635–B	636–B	3·0	106·4	−·009	+·024	518·389	636–B
636–B	637–B	2·5	108·9	−·003	+·021	528·271	637–B
637–B	638–B	2·7	111·6	−·025	−·004	419·295	638–B
638–B	639–B*	1·8	113·4	+·011	+·007	393·247	639–B*
639–B*	640–B	0·3	113·7	−·002	+·005	387·042	640–B
640–B	641–B	1·9	115·6	−·003	+·002	388·902	641–B
641–B	642–B	2·7	118·3	−·001	+·001	405·291	642–B
642–B	643–B	2·7	121·0	+·002	+·003	401·892	643–B
643–B	644–B	2·4	123·4	−·007	−·004	440·719	644–B
644–B	645–B	0·3	123·7	−·006	−·010	415·972	645–B
645–B	646–B	3·1	126·8	+·015	+·005	428·791	646–B
646–B	647–B	3·2	130·0	+·009	+·014	439·880	647–B
647–B	648–B	1·2	131·2	+·015	+·029	483·890	648–B
648–B	649–B	2·3	133·5	−·013	+·016	479·831	649–B
649–B	650–B	2·5	136·0	−·016	·000	490·563	650–B
650–B	3†	1·7	137·7	+·007	+·007	484·039	3†

Connections with Public Works Dept's bench-marks:—
B.M.—DCI—D. & H. station, Rouse Point, Elev. 123·761.
B.M.—DCCCXIX—Dwelling near G.T.R. station, Lacolle, Elev. 156·760.
B.M.—MCCCXXXII—C.P.R. bridge over La Tortue river, Elev. 93·318.
B.M.—DLXXXVIII—G.T.R. culvert 1½ miles north of Brosseau, Elev. 58·194.
B.M.—DLXXXVII—G.T.R. culvert 2¼ miles north of Brosseau, Elev. 58·420.
B.M.—DLXXXVI—G.T.R. subway, St. Lambert, Elev. 72·050.
B.M.—MCCCXXXIX—Roman Catholic church, St. Hubert, Elev. 84·420.
B.M.—MCCCXLII—G.T.R. subway, St. Hilaire, Elev. 52·301.

*See also elevation of this bench-mark on page 34.
†The elevation of bench-mark 3 given on page 319, 1917 publication, is 484·318.

RESULTS OF PRECISE LEVELLING

STE. ROSALIE JCT. TO FARNHAM, QUE.

Run by H. P. Moulton

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 614-B	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	614–B					108·778	614–B
614–B	615–B	1·6	1·6	−·003	−·003	108·751	615–B
615–B	616–B	2·5	4·1	+·020	+·017	108·878	616–B
616–B	617–B	2·9	7·0	−·015	+·002	109·274	617–B
617–B	618–B	3·1	10·1	·000	+·002	130·618	618–B
618–B	619–B	2·5	12·6	+·016	+·018	189·312	619–B
619–B	620–B	2·7	15·3	+·002	+·020	196·043	620–B
620–B	621–B	3·5	18·8	+·005	+·025	215·456	621–B
621–B	622–B	2·1	20·9	·000	+·025	232·838	622–B
622–B	623–B	4·1	25·0	−·008	+·017	220·586	623–B
623–B	62*	1·8	26·8	+·006	+·023	195·017	62*

*The elevation of bench-mark 62 given on page 317, 1917 publication, is 195·121.

RESULTS OF PRECISE LEVELLING

CHAUDIERE TO RICHMOND, QUE

Run by H. P. Moulton

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 258–B	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	258–B					169·643	258–B
258–B	651–B	4·2	4·2	+·018	+·018	275·148	651–B
651–B	652–B	4·3	8·5	+·021	+·039	348·559	652–B
652–B	653–B	4·2	12·7	−·006	+·033	392·713	653–B
653–B	654–B	1·2	13·9	+·018	+·051	416·028	654–B
654–B	655–B	0·2	14·1	+·006	+·057	436·318	655–B
654–B	656–B	5·1	19·0	−·008	+·043	484·925	656–B
656–B	657–B	3·4	22·4	−·027	+·016	429·371	657–B
657–B	658–B	3·0	25·4	+·008	+·024	443·415	658–B
658–B	659–B	3·0	28·4	−·016	+·008	457·137	659–B
659–B	660–B	1·6	30·0	+·023	+·031	444·203	660–B
660–B	661–B	2·8	32·8	−·010	+·021	486·719	661–B
661–B	662–B	1·7	34·5	+·017	+·038	467·757	662–B
662–B	663–B	3·2	37·7	+·015	+·053	458·812	663–B
663–B	664–B	2·3	40·0	+·028	+·081	442·645	664–B
664–B	665–B	2·8	42·8	−·006	+·075	442·876	665–B
665–B	666–B	0·7	43·5	−·009	+·066	505·083	666–B
665–B	667–B	3·9	46·7	+·001	+·076	512·660	667–B
667–B	668–B	1·7	48·4	+·007	+·083	513·780	668–B
668–B	669–B	3·0	51·4	+·010	+·093	497·001	669–B
669–B	670–B	6·0	57·4	+·002	+·095	437·739	670–B
670–B	671–B	0·2	57·6	−·006	+·089	439·024	671–B
670–B	672–B	0·5	57·9	+·005	+·100	418·850	672–B
672–B	673–B	4·6	62·5	−·003	+·097	420·238	673–B
673–B	674–B	2·8	65·3	+·006	+·103	519·044	674–B
674–B	675–B	0·8	66·1	−·014	+·089	473·489	675–B
675–B	676–B	4·3	70·4	−·007	+·082	433·707	676–B
676–B	677–B	2·6	73·0	+·006	+·088	448·929	677–B
677–B	678–B	3·0	76·0	−·008	+·080	390·766	678–B
678–B	679–B	1·6	77·6	+·003	+·083	444·540	679–B
679–B	680–B	2·7	80·3	−·025	+·058	464·930	680–B
680–B	681–B	2·6	82·9	+·004	+·062	481·691	681–B
681–B	682–B	3·0	85·9	+·003	+·065	482·910	682–B
682–B	683–B	2·0	87·9	−·018	+·047	461·647	683–B
683–B	639–B*	1·6	89·5	−·023	+·024	393·289	639–B*

*See also elevation of this bench-mark on page 33.

Connection at Chaudiere with Public Works Dept's bench-mark:—

B.M.—MCLXXII—I.R.C. bridge over Chaudière river, Elev. 233·595.

RESULTS OF PRECISE LEVELLING

LOOP LINE AROUND MONTREAL, QUE.

Run by W. N. McGrath

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 597–B–2	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No. 597–B–2	Miles	Miles	Feet	Feet	Feet 55·560	No. 597–B–2
597-B-2	DLXXXVI	0·4	0·4	+·007	+·007	72·050	DLXXXVI
DLXXXVI	DLXXXV	0·5	0·9	·000	+·007	67·619	DLXXXV
DLXXXV	DLXXXIV	1·4	2·3	+·006	+·013	67·247	DLXXXIV
DLXXXIV	DLXXXIII	2·0	4·3	+·016	+·029	61·531	DLXXXIII
DLXXXIII	DCCCXLVI	0·9	5·2	−·007	+·022	55·562	DCCCXLVI
DCCCXLVI	807	0·3	5·5	−·003	+·019	112·979	807
807	808	0·9	6·4	−·005	+·014	111·834	808
808	809	0·2	6·6	+·011	+·025	124·830	809
807	810	1·0	6·5	−·013	+·006	153·717	810
810	811	1·6	8·1	−·023	−·017	168·142	811
811	812	1·1	9·2	+·018	+·001	151·216	812
812	812	0·7	9·9	+·013	+·014	126·661	813
813	814	1·4	11·3	−·019	−·005	151·619	814
814	815	2·8	14·1	+·014	+·009	190·911	815
815	816	0·7	14·8	+·001	+·010	188·466	816
816	817	0·1	14·9	−·001	+·009	178·253	817
816	818	1·3	16·1	·000	+·010	203·377	818
818	819	0·5	16·6	−·015	−·005	225·695	819
819	820	0·2	16·8	−·008	−·013	226·571	820
819	821	1·7	18·3	+·014	+·009	166·600	821
821	822	1·0	19·3	−·001	+·008	67·814	822
822	823	1·1	20·4	−·005	+·003	55·284	823
823	824	0·9	21·3	+·005	+·008	65·287	824
824	N	1·3	22·6	+·001	+·009	49·030	N
N	825	0·2	22·8	+·007	+·016	49·902	825
825	DLXXXIV	1·2	24·0	−·007	+·009	67·247	DLXXXIV

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RESULTS OF PRECISE LEVELLING

BRANTFORD TO LUCAN CROSSING, ONT.

Run by W. N. McGrath

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 218	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	218					703·470	218
218	77–F	3·8	3·8	+·008	+·008	751·378	77–F
77–F	78–F	1·9	5·7	+·018	+·026	750·731	78–F
78–F	79–F	1·9	7·6	+·002	+·028	788·766	79–F
79–F	80–F	4·6	12·2	−·003	+·025	868·836	80–F
80–F	81–F	2·7	14·9	−·002	+·023	878·005	81–F
81–F	82–F	0·5	15·4	−·002	+·021	870·997	82–F
81–F	82–F–2	1·2	16·1	−·002	+·021	922·517	82–F–2
82–F–2	83–F	3·4	19·5	+·011	+·032	930·206	83–F
83–F	84–F	0·2	19·7	−·003	+·029	933·755	84–F
83–F	85–F	3·5	23·0	−·031	+·001	946·466	85–F
85–F	86–F	0·7	23·7	+·005	+·006	980·430	86–F
86–F	87–F	3·6	27·3	+·014	+·020	1008·553	87–F
87–F	88–F	3·4	30·7	+·023	+·043	1059·596	88–F
88–F	89–F	0·9	31·6	+·010	+·053	1076·788	89–F
89–F	90–F	1·0	32·6	+·002	+·055	1070·043	90–F
90–F	91–F	——	32·6	−·002	+·053	1063·648	91–F
90–F	92–F	0·4	33·0	−·001	+·054	1078·160	92–F
89–F	93–F	6·3	37·9	+·023	+·076	1071·474	93–F
93–F	94–F	2·6	40·5	−·004	+·072	1008·575	94–F
94–F	95–F	3·9	44·4	+·005	+·077	1102·960	95–F
95–F	96–F	0·5	44·9	·000	+·077	1124·752	96–F
96–F	97–F	0·3	45·2	+·004	+·081	1101·370	97–F
95–F	98–F	1·6	46·0	+·013	+·090	1059·902	98–F
98–F	99–F	0·2	46·2	−·004	+·086	1075·571	99–F
95–F	100–F	3·4	47·8	+·023	+·100	1202·325	100–F
100–F	101–F	5·5	53·3	+·032	+·132	1183·054	101–F
101–F	102–F	3·5	56·8	+·008	+·140	1090·714	102–F
102–F	103–F	0·5	57·3	−·011	+·129	1125·216	103–F
103–F	104–F	4·5	61·8	+·011	+·140	1185·466	104–F
104–F	105–F	5·1	66·9	+·014	+·154	1205·032	105–F
105–F	106–F	3·3	70·2	+·024	+·178	1194·242	106–F
106–F	107–F	0·7	70·9	−·005	+·173	1180·745	107–F
106–F	108–F	0·7	70·9	+·010	+·188	1182·359	108–F
108–F	109–F	7·0	77·9	+·022	+·210	1103·918	109–F
109–F	110–F	3·5	81·4	+·001	+·211	1057·075	110–F
110–F	111–F	0·9	82·3	+·002	+·213	1040·402	111–F
111–F	112–F	6·4	88·7	+·022	+·235	981·652	112–F
112–F	113–F	3·7	92·4	−·007	+·228	998·996	113–F
113–F	113–F–2	2·2	94·6	+·004	+·232	1030·227	113–F–2
113–F–2	114–F	1·4	96·0	+·001	+·233	997·137	114–F
114–F	337*	2·9	98·9	+·005	+·238	864·741	337*

*The elevation of bench-mark 337 given on page 84, 1913 publication, is 864·945.

RESULTS OF PRECISE LEVELLING

GUELPH JCT. TO PALMERSTON, ONT.

Run by W. N. McGrath

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 89–F	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	89–F					1076·788	89–F
89–F	115–F	2·7	2·7	−·026	−·026	1112·124	115–F
115–F	116–F	6·2	8·9	+·010	−·016	1165·981	116–F
116–F	117–F	4·5	13·4	−·010	−·026	1272·843	117–F
117–F	118–F	1·8	15·2	+·008	−·018	1300·922	118–F
118–F	119–F	1·0	16·2	+·005	−·013	1310·044	119–F
119–F	120–F	0·4	16·6	+·001	−·012	1362·232	120–F
120–F	121–F	2·9	19·5	−·033	−·045	1362·240	121–F
121–F	122–F	5·5	25·0	−·008	−·053	1506·389	122–F
122–F	123–F	6·1	31·1	+·017	−·036	1349·339	123–F
123–F	124–F	5·1	36·2	−·015	−·051	1328·039	124–F
124–F	305*	6·6	42·8	+·013	−·038	1317·328	305*

*The elevation of bench-mark 305 given, on page 83, 1913 publication, is 1317·286.

RESULTS OF PRECISE LEVELLING

FERGUS TO MELVILLE, ONT.

Run by W. N. McGrath

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 120–F	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	120–F					1362·232	120–F
120–F	125–F	3·7	3·7	−·014	−·014	1396·287	125–F
125–F	126–F	5·3	9·0	−·014	−·028	1490·923	126–F
126–F	127–F	4·2	13·2	−·024	−·052	1441·928	127–F
127–F	128–F	2·8	16·0	+·003	−·049	1433·733	128–F
128–F	129–F	3·4	19·4	+·012	−·037	1296·986	129–F
129–F	130–F	4·3	23·7	+·013	−·024	1283·344	130–E
130–F	131–F	4·4	28·1	−·014	−·038	1299·534	131–F
131–F	132–F	1·8	29·9	+·002	−·036	1326·069	132–F
132–F	265*	3·8	33·7	−·029	−·065	1349·412	265*

*The elevation of bench-mark 265 given on page 82, 1913 publication, is 1349·299.

RESULTS OF PRECISE LEVELLING

ST. CATHARINES TO PORT DALHOUSIE, ONT.

Run by W. N. McGrath

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 208	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	208					358·616	208
208	133–F	1·8	1·8	−·003	−·003	320·978	133–F
133–F	134–F	1·6	3·4	+·007	+·004	259·719	134–F

RESULTS OF PRECISE LEVELLING

WELLAND JCT. TO PORT COLBORNE, ONT.

Run by W. N. McGrath

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 214	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	214					580·353	214
214	135–F	5·1	5·1	−·013	−·013	583·314	135–F
135–F	136–F	0·3	5·4	−·010	−·023	605·566	136–F
136–F	137–F	0·5	5·9	−·013	−·036	579·302	137–F

For connections at Port Dalhousie and Port Colborne with Hydrographic Survey bench-marks, see Introduction.

RESULTS OF PRECISE LEVELLING

FRANZ TO PORT ARTHUR, ONT.

Run by A. J. Rainboth

Bench-Mark		Distance between successive bench marks	Distance from bench-mark 634	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	708		194·2		+·362	1219·304	708
708	709	3·3	197·5	+·023	+·385	1189·871	709
709	710	3·7	201·2	+·014	+·399	1157·543	710
710	711	2·9	204·1	+·002	+·401	1206·771	711
711	712	2·9	207·0	−·005	+·396	1250·080	712
712	713	3·7	210·7	+·019	+·415	1385·131	713
713	714	3·5	214·2	+·006	+·421	1410·287	714
714	715	2·9	217·1	+·005	+·426	1424·738	715
715	716	3·0	220·1	+·022	+·448	1428·784	716
716	717	3·5	223·6	+·004	+·452	1376·524	717
717	718	2·4	226·0	+·005	+·457	1369·824	718
718	719	2·7	228·7	−·002	+·455	1357·126	719
719	720	3·2	231·9	−·022	+·433	1382·409	720
720	721	3·7	235·6	−·009	+·424	1355·094	721
721	722	4·5	240·1	+·014	+·438	1255·447	722
722	723	2·7	242·8	−·002	+·436	1225·260	723
723	723–A	0·2	243·0	·000	+·436	1222·132	723–A
723	724	3·1	245·9	·000	+·436	1225·742	724
724	725	3·1	249·0	+·006	+·442	1199·050	725
725	726	3·0	252·0	+·004	+·446	1195·487	726
726	727	3·1	255·1	+·002	+·448	1145·722	727
727	728	3·2	258·3	−·002	+·446	1129·694	728
728	729	3·7	262·0	−·001	+·445	1108·312	729
729	730	2·2	264·2	+·001	+·446	1086·915	730
730	731	2·1	266·3	+·009	+·455	1084·388	731
731	732	1·3	267·6	−·012	+·443	1076·573	732
732	733	3·3	270·9	−·015	+·428	1054·424	733
733	734	3·3	274·2	+·009	+·437	1053·395	734
734	735	2·7	276·9	+·013	+·450	1031·527	735
735	736	3·1	280·0	−·007	+·443	1028·112	736
736	737	3·1	283·1	+·002	+·445	966·300	737
737	738	2·5	285·6	−·002	+·443	871·151	738
738	739	3·5	289·1	+·002	+·445	875·666	739
739	740	4·3	293·4	+·027	+·472	801·639	740
740	741	1·6	295·0	−·008	+·464	794·347	741
741	742	2·4	297·4	−·013	+·451	683·853	742
742	742–A	0·7	298·1	−·002	+·449	708·778	742–A
742–A	743	2·9	301·0	−·016	+·433	738·913	743
743	744	3·2	304·2	−·004	+·429	681·593	744
744	745	2·7	306·9	−·007	+·422	698·604	745
745	746	3·1	310·0	−·021	+·401	715·375	746
746	747	3·0	313·0	+·004	+·405	739·529	747
747	748	3·0	316·0	+·002	+·407	652·930	748
748	749	2·9	318·9	−·013	+·394	784·428	749
749	750	3·0	321·9	+·007	+·401	791·108	750
750	751	3·0	324·9	−·005	+·396	692·462	751
751	752	3·0	327·9	−·008	+·388	650·501	752
752	753	3·0	330·9	−·008	+·380	650·659	753
753	754	3·0	333·9	−·009	+·371	713·691	754
754	755	3·0	336·9	−·005	+·366	709·893	755
755	756	3·0	339·9	−·013	+·353	702·105	756
756	757	3·1	343·0	+·003	+·356	632·881	757

RESULTS OF PRECISE LEVELLING

FRANZ TO PORT ARTHUR, ONT.—*Concluded*

Run by A. J. Rainboth

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 634	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
757	758	2·8	345·8	−·012	+·344	651·299	758
758	759	2·9	348·7	−·005	+·339	746·206	759
759	760	4·5	353·2	+·005	+·344	885·359	760
760	761	3·5	356·7	+·019	+·363	970·171	761
761	762	2·4	359·1	+·022	+·385	959·532	762
762	763	1·9	361·0	−·014	+·371	997·875	763
763	764	0·2	361·2	+·003	+·374	979·935	764
764	765	2·9	364·1	+·012	+·386	955·775	765
765	766	3·0	367·1	+·015	+·401	823·515	766
766	767	4·0	371·1	−·017	+·384	698·170	767
767	768	3·0	374·1	+·015	+·399	660·454	768
768	769	3·0	377·1	+·025	+·424	640·329	769
769	770	2·8	379·9	+·020	+·444	631·229	770
770	771	3·2	383·1	−·022	+·422	613·002	771
771	772	3·0	386·1	−·022	+·400	648·265	772
772	773	2·9	389·0	+·001	+·401	635·305	773
773	774	3·1	392·1	+·016	+·417	626·056	774
774	775	2·6	394·7	−·004	+·413	606·940	775
775	776	4·4	399·1	−·009	+·404	607·148	776
776	777	3·0	402·1	+·016	+·420	636·014	777
777	778	3·3	405·4	+·006	+·426	723·053	778
778	779	2·1	407·5	·000	+·426	640·209	779
779	780	2·2	409·7	−·017	+·409	624·553	780
780	781	2·1	411·8	−·013	+·396	631·458	781
781	782	2·8	414·6	+·002	+·398	615·595	782
782	783	3·0	417·6	−·016	+·382	623·466	783
783	784	3·4	421·0	−·010	+·372	700·429	784
784	785	2·5	423·5	−·019	+·353	683·144	785
785	786	2·6	426·1	+·011	+·364	613·162	786
786	787	2·7	428·8	+·028	+·392	628·169	787
787	788	2·7	431·5	−·015	+·377	640·920	788
788	789	3·4	434·9	−·003	+·374	661·285	789
789	790	2·5	437·4	+·005	+·379	647·734	790
790	791	3·9	441·3	−·004	+·375	603·868	791
791	792	2·8	444·1	+·012	+·387	623·042	792
792	793	2·8	446·9	+·004	+·391	671·579	793
793	794	3·2	450·1	−·023	+·368	736·405	794
794	795	3·8	453·9	+·001	+·369	774·598	795
795	796	3·4	457·3	+·013	+·382	845·080	796
796	797	2·6	459·9	+·013	+·395	937·812	797
797	798	3·0	462·9	−·002	+·393	1047·761	798
798	799	4·0	466·9	+·013	+·406	993·449	799
799	800	2·0	468·9	−·017	+·389	956·424	800
800	801	2·7	471·6	·000	+·389	927·855	801
801	802	2·6	474·2	+·005	+·394	902·167	802
802	803	2·8	477·0	−·001	+·393	904·758	803
803	804	4·0	481·0	−·006	+·387	783·612	804
804	805	2·7	483·7	−·020	+·367	697·298	805
805	806	3·8	487·5	+·005	+·372	636·543	806
806	93–E*	2·1	489·6	+·001	+·373	616·301	93–E*

*The elevation of bench-mark 93–E given on page 184, 1916 publication, is 617·119.
For connection at Port Arthur with Hydrographic Survey bench-mark, see Introduction.

RESULTS OF PRECISE LEVELLING

JASPER, ALTA., TO LOOS, B.C.

Run by N. H. Smith and A. J. Rainboth

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 28–D	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	104–H		565·3		+·361	3483·531	104–H
104–H	105–H	2·7	568·0	−·010	+·351	3504·151	105–H
105–H	106–H	3·0	571·0	−·014	+·337	3544·618	106–H
106–H	107–H	2·1	573·1	+·008	+·345	3577·810	107–H
107–H	108–H	3·7	576·8	+·009	+·354	3625·835	108–H
108–H	109–H	4·1	580·9	−·007	+·347	3695·456	109–H
109–H	110–H	2·9	583·8	+·010	+·357	3700·530	110–H
110–H	111–H	3·0	586·8	+·012	+·369	3643·387	111–H
111–H	112–H	2·4	589·2	+·008	+·377	3585·783	112–H
112–H	113–H	7·1	596·3	−·005	+·372	3480·823	113–H
113–H	114–H	2·8	599·1	+·007	+·379	3429·085	114–H
114–H	115–H	2·9	602·0	+·009	+·388	3398·796	115–H
115–H	116–H	3·8	605·8	+·004	+·392	3401·944	116–H
116–H	117–H*	3·6	609·4	−·010	+·402	3399·866	117–H*
117–H*	118–H	2·1	611·5	−·015	+·387	3396·388	118–H
118–H	119–H	4·5	616·0	·000	+·387	3171·898	119–H
119–H	120–H	4·3	620·3	−·018	+·369	2979·400	120–H
120–H	121–H	2·4	622·7	−·022	+·347	2855·384	121–H
121–H	122–H	3·6	626·3	−·005	+·342	2678·376	122–H
122–H	123–H	2·5	628·8	−·009	+·333	2555·876	123–H
123–H	124–H	2·8	631·6	+·007	+·340	2445·614	124–H
124–H	125–H	7·0	638·6	−·005	+·335	2404·906	125–H
125–H	126–H	7·4	646·0	+·006	+·341	2520·014	126–H
126–H	127–H	6·5	652·5	−·008	+·333	2568·628	127–H
127–H	128–H	5·4	657·9	+·010	+·343	2497·190	128–H
128–H	129–H	3·9	661·8	+·002	+·345	2418·920	129–H
129–H	130–H	3·0	664·8	+·020	+·365	2366·936	130–H
130–H	131–H	7·8	672·6	+·021	+·386	2371·772	131–H
131–H	132–H	2·5	675·1	+·023	+·409	2353·574	132–H
132–H	133–H	4·8	679·9	+·008	+·417	2341·379	133–H
133–H	134–H	6·4	686·3	+·006	−·411	2314·920	134–H
134–H	135–H	4·4	690·7	−·012	+·399	2295·988	135–H
135–H	136–H	2·7	693·4	+·001	+·400	2251·664	136–H
136–H	137–H	4·9	698·3	+·010	+·410	2205·864	137–H
137–H	138–H	1·9	700·2	+·002	+·412	2199·250	138–H
138–H	139–H	7·3	707·5	+·009	+·421	2155·523	139–H

*See also elevation of this bench-mark on page 44.

RESULTS OF PRECISE LEVELLING

ABBOTSFORD TO RESPLENDENT, B.C.

Run by D. McMillan and A. J. Rainboth

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 25–J	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	25–J					172·075	25–J
25–J	28–J	1·3	1·3	+·006	+·006	88·025	28–J
28–J	29–J	2·6	3·9	−·003	+·003	37·718	29–J
29–J	30–J	2·4	6·3	−·017	−·014	17·432	30–J
30–J	31–J	3·7	10·0	+·002	+·012	35·049	31–J
31–J	32–J	4·6	14·6	+·003	−·009	35·980	32–J
32–J	33–J	4·0	18·6	+·011	+·002	34·785	33–J
33–J	34–J	3·8	22·4	+·003	+·005	30·754	34–J
34–J	35–J	0·6	23·0	+·011	+·016	35·441	35–J
34–J	36–J	7·6	30·0	+·007	+·012	47·730	36–J
36–J	37–J	5·8	35·8	−·014	−·002	80·901	37–J
37–J	38–J	2·4	38·2	·000	−·002	79·331	38–J
38–J	39–J	3·4	41·6	+·014	+·012	95·819	39–J
39–J	40–J	5·7	47·3	−·012	·000	112·671	40–J
40–J	41–J	1·5	48·8	+·004	+·004	117·488	41–J
41–J	42–J	4·8	53·6	−·011	−·007	150·948	42–J
42–J	43–J	1·9	55·5	−·008	−·015	137·713	43–J
43–J	44–J	2·8	58·3	+·021	+·006	147·338	44–J
44–J	45–J	4·6	62·9	−·006	·000	171·364	45–J
45–J	46–J	3·8	66·7	−·014	−·014	182·877	46–J
46–J	47–J	4·9	71·6	−·014	−·028	212·997	47–J
47–J	48–J	3·2	74·8	+·013	−·015	243·892	48–J
48–J	49–J	3·5	78·3	−·006	−·021	282·546	49–J
49–J	50–J	1·3	79·6	−·009	−·040	289·062	50–J
50–J	51–J	3·5	83·1	+·020	−·020	349·178	51–J
51–J	52–J	3·2	86·3	+·031	+·011	397·961	52–J
52–J	53–J	3·3	89·6	−·009	+·002	389·617	53–J
53–J	54–J	3·7	93·3	+·001	+·003	427·126	54–J
54–J	55–J	1·0	94·3	−·007	−·004	432·189	55–J
55–J	56–J	3·9	98·2	+·027	+·023	461·156	56–J
56–J	57–J	3·6	101·8	−·013	+·010	512·028	57–J
57–J	58–J	5·3	107·1	+·029	+·039	573·731	58–J
58–J	59–J	3·7	110·8	+·006	+·045	602·930	59–J
59–J	60–J	3·6	114·4	+·031	+·076	597·075	60–J
60–J	61–J	3·7	118·1	−·014	+·062	598·790	61–J
61–J	62–J	5·2	123·3	+·027	+·089	559·634	62–J
62–J	63–J	1·0	124·3	−·010	+·079	561·813	63–J
63–J	64–J	6·3	130·6	−·019	+·060	618·950	64–J
64–J	65–J	3·1	133·7	+·014	+·074	647·670	65–J
65–J	66–J	7·8	141·5	+·014	+·088	713·987	66–J
66–J	67–J	4·6	146·1	+·021	+·109	735·423	67–J
67–J	68–J	0·9	147·0	+·014	+·095	745·330	68–J
68–J	69–J	3·1	150·1	+·001	+·096	768·917	69–J
69–J	70–J	3·8	153·9	−·013	+·083	831·549	70–J
70–J	71–J	8·1	162·0	−·001	+·082	893·727	71–J
71–J	72–J	2·5	164·5	−·006	+·076	890·583	72–J
72–J	73–J	2·1	166·6	−·008	+·068	924·677	73–J
73–J	74–J	4·8	171·4	+·026	+·094	978·222	74·J
74–J	75–J	2·9	174·3	+·017	+·111	988·498	75–J
75–J	76–J	1·5	175·8	+·005	+·116	1005·848	76–J
76–J	77–J	5·4	181·2	−·037	+·079	1032·369	77–J
77–J	78–J	5·4	186·6	+·026	+·105	1070·835	78–J
78–J	79–J	0·8	187·4	+·008	+·113	1082·247	79–J
79–J	80–J	5·2	192·6	+·004	+·117	1128·700	80–J

RESULTS OF PRECISE LEVELLING

ABBOTSFORD TO RESPLENDENT, B.C.—*Continued*

Run by D. McMillan and A. J. Rainboth

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 25–J	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
80–J	81–J	3·0	195·6	−·003	+·114	1176·509	81–J
81–J	82–J	2·9	198·5	+·011	+·125	1172·052	82–J
82–J	83–J	2·6	201·1	+·016	+·141	1173·146	83–J
83–J	84–J	4·8	205·9	−·033	+·108	1170·412	84–J
84–J	85–J	5·3	211·2	+·015	+·123	1175·534	85–J
85–J	86–J	7·0	218·2	+·009	+·132	1136·526	86–J
86–J	87–J*	3·5	221·7	−·033	+·099	1141·716	87–J*
87–J*	88–J	4·9	226·6	+·027	+·126	1159·043	88–J
88–J	89–J	7·1	233·7	·000	+·126	1177·377	89–J
89–J	90–J	5·3	239·0	+·030	+·156	1266·973	90–J
90–J	91–J	3·9	242·9	+·015	+·171	1188·508	91–J
91–J	92–J	5·3	248·2	+·004	+·175	1211·247	92–J
92–J	93–J	3·3	251·5	+·013	+·188	1225·266	93–J
93–J	94–J	3·8	255·3	+·007	+·195	1246·093	94–J
94–J	95–J	2·9	258·2	+·005	+·200	1251·204	95–J
95–J	96–J	3·3	261·5	+·016	+·216	1257·770	96–J
96–J	97–J	4·1	265·6	−·019	+·197	1262·681	97–J
97–J	98–J	5·5	271·1	+·033	+·230	1264·481	98–J
98–J	99–J	3·3	274·4	+·027	+·257	1257·549	99–J
99–J	100–J	3·5	277·9	+·014	+·271	1278·476	100–J
100–J	101–J	3·4	281·3	+·021	+·292	1293·026	101–J
101–J	102–J	4·3	285·6	−·020	+·272	1295·472	102–J
102–J	103–J	3·7	289·3	−·008	+·264	1312·423	103–J
103–J	104–J	3·1	292·4	+·019	+·283	1330·425	104–J
104–J	105–J	2·9	295·3	+·002	+·285	1350·297	105–J
105–J	106–J	4·4	299·7	+·019	+·304	1384·110	106–J
106–J	107–J	3·5	303·2	−·028	+·276	1443·269	107–J
107–J	108–J	2·7	305·9	+·027	+·303	1497·445	108–J
108–J	109–J	3·4	309·3	+·011	+·314	1538·348	109–J
109–J	110–J	3·1	312·4	+·022	+·336	1602·868	110–J
110–J	111–J	1·9	314·3	+·005	+·341	1634·169	111–J
111–J	112–J	3·8	318·1	+·007	+·348	1691·549	112–J
112–J	113–J	3·5	321·6	+·002	+·350	1745·800	113–J
113–J	114–J	3·2	324·8	+·018	+·368	1779·214	114–J
114–J	115–J	3·9	328·7	+·012	+·380	1862·343	115–J
115–J	116–J	5·5	334·2	−·015	+·365	1897·159	116–J
116–J	117–J	4·8	339·0	+·035	+·400	1934·640	117–J
117–J	118–J	3·5	342·5	+·010	+·410	1996·917	118–J
118–J	119–J	2·8	345·3	+·034	+·444	2041·799	119–J
119–J	120–J	3·0	348·3	+·015	+·459	2085·193	120–J
120–J	121–J	3·1	351·4	−·029	+·430	2140·346	121–J
121–J	122–J	2·9	354·3	+·025	+·455	2185·487	122–J
122–J	123–J	3·1	357·4	−·009	+·446	2202·932	123–J
123–J	124–J	4·1	361·5	−·007	+·439	2233·474	124–J
124–J	125–J	0·1	361·6	−·003	+·436	2233·499	125–J
125–J	126–J	1·4	363·0	+·010	+·446	2232·570	126–J
126–J	127–J	4·9	367·9	+·012	+·458	2235·096	127–J
127–J	128–J	2·9	370·8	+·027	+·485	2258·472	128–J
128–J	129–J	3·9	374·7	−·036	+·449	2267·949	129–J
129–J	130–J	2·6	377·3	+·007	+·456	2287·042	130–J
130–J	131–J	2·8	380·1	+·012	+·468	2308·285	131–J
131–J	132–J	3·5	383·6	−·028	+·440	2342·315	132–J
132–J	133–J	2·8	386·4	+·001	+·441	2409·075	133–J
133–J	134–J	3·1	389·5	+·003	+·444	2502·853	134–J

*See also elevation of this bench-mark on page 45.

RESULTS OF PRECISE LEVELLING

ABBOTSFORD TO RESPLENDENT, B.C.—*Concluded*

Run by D. McMillan and A. J. Rainboth

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 25–J	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
134–J	135–J	2·8	392·3	−·024	+·420	2595·741	135–J
135–J	136–J	2·2	394·5	+·009	+·429	2669·167	136–J
136–J	137–J	5·6	400·1	−·024	+·405	2829·511	137–J
137–J	138–J	2·2	402·3	+·002	+·407	2865·487	138–J
138–J	139–J	2·1	404·4	+·011	+·418	2826·141	139–J
139–J	140–J	2·7	407·1	+·010	+·408	2785·663	140–J
140–J	141–J	3·8	410·9	+·003	+·411	2719·456	141–J
141–J	142–J	2·6	413·5	·000	+·411	2687·284	142–J
142–J	143–J	7·2	420·7	−·013	+·398	2613·318	143–J
143–J	144–J	1·9	422·6	+·010	+·408	2624·094	144–J
144–J	145–J	3·6	426·2	+·026	+·434	2750·118	145–J
145–J	146–J	2·8	429·0	+·019	+·453	2822·580	146–J
146–J	147–J	3·2	432·2	−·011	+·442	2922·567	147–J
147–J	148–J	2·8	435·0	+·014	+·456	3016·659	148–J
148–J	149–J	3·2	438·2	+·028	+·484	3100·449	149–J
149–J	150–J	2·8	441·0	·000	+·484	3193·544	150–J
150–J	151–J	3·1	444·1	−·010	+·474	3289·242	151–J
151–J	152–J	2·8	446·9	·000	+·474	3401·106	152–J
152–J	153–J	3·2	450·1	+·002	+·476	3408·634	153–J
153–J	117–H*	.....	450·1	−·002	+·474	3399·817	117–H*

*See also elevation of this bench-mark on page 41.

RESULTS OF PRECISE LEVELLING

REVELSTOKE TO KAMLOOPS, B.C.

Run by D. McMillan

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 51–D	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	314–C		268·2		+·266	1512·387	314–C
314–C	315–C	2·9	271·1	·000	+·266	1602·967	315–C
315–C	316–C	3·2	274·3	+·003	+·269	1742·270	316–C
316–C	317–C	2·7	277·0	+·021	+·290	1791·210	317–C
317–C	318–C	2·8	279·8	+·002	+·292	1642·759	318–C
318–C	319–C	2·8	282·6	+·006	+·298	1620·147	319–C
319–C	320–C	2·7	285·3	+·005	+·293	1481·555	320–C
320–C	321–C	0·7	286·0	+·009	+·302	1425·076	321–C
321–C	322–C	4·1	290·1	·000	+·302	1325·728	322–C
322–C	323–C	1·1	291·2	−·007	+·295	1276·419	323–C
323–C	324–C	2·3	293·5	+·006	+·301	1250·744	324–C
324–C	325–C	2·1	295·6	+·012	+·313	1226·728	325–C
325–C	326–C	4·5	300·1	+·017	+·296	1199·427	326–C
326–C	327–C	4·3	304·4	+·003	+·299	1173·813	327–C
327–C	328–C	3·3	307·7	+·020	+·319	1159·948	328–C

RESULTS OF PRECISE LEVELLING

REVELSTOKE TO KAMLOOPS, B.C.—*Concluded*

Run by D. McMillan

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 51–D	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
328–C	329–C	3·4	311·1	+·030	+·349	1151·130	329–C
329–C	330–C	0·6	311·7	−·005	+·344	1151·864	330–C
330–C	331–C	3·6	315·3	−·008	+·336	1155·637	331–C
331–C	332–C	4·1	319·4	−·025	+·311	1153·563	332–C
332–C	333–C	4·9	324·3	+·009	+·320	1151·100	333–C
333–C	334–C	4·5	328·8	−·004	+·316	1164·388	334–C
334–C	335–C	1·8	330·6	−·003	+·313	1161·178	335–C
335–C	336–C	1·4	332·0	−·002	+·311	1144·518	336–C
336–C	337–C	3·9	335·9	+·004	+·315	1155·966	337–C
337–C	338–C	7·0	342·9	−·007	+·308	1459·206	338–C
338–C	339–C	4·0	346·9	+·011	+·319	1708·263	339–C
339–C	340–C	5·4	352·3	−·015	+·304	1409·301	340–C
340–C	341–C	6·2	358·5	−·019	+·285	1143·631	341–C
341–C	342–C	2·1	360·6	+·024	+·309	1173·863	342–C
342–C	343–C	3·2	363·8	+·010	+·319	1144·836	343–C
343–C	344–C	2·1	365·9	+·017	+·336	1146·128	344–C
344–C	345–C	3·8	369·7	+·006	+·342	1162·252	345–C
345–C	346–C	3·6	373·3	+·002	−·340	1148·847	346–C
346–C	347–C	4·2	377·5	−·013	+·327	1156·219	347–C
347–C	348–C	1·4	378·9	+·009	+·336	1151·083	348–C
348–C	349–C	3·3	382·2	−·020	+·316	1146·333	349–C
349–C	350–C	2·0	384·2	+·003	+·319	1153·857	350–C
350–C	351–C	5·0	389·2	−·002	+·317	1153·736	351–C
351–C	352–C	2·6	391·8	−·001	+·316	1140·871	352–C
352–C	353–C	2·9	394·7	−·006	+·310	1143·837	353–C
353–C	354–C	1·1	395·8	−·008	+·302	1162·429	354–C
354–C	355–C	0·4	396·2	·000	+·302	1182·008	355–C
354–C	87–J*	3·5	399·3	−·009	−·293	1142·810	87–J*

*See also elevation of this bench-mark on page 43.

TABLE III

RAIL ELEVATIONS, ROUSE POINT, N.Y., TO SHERBROOKE, QUE.

(Elevations taken in 1915 and 1916)

	FEET
Delaware & Hudson Railroad—Rouse Point	123·2
" Rutland railroad (diamond crossing)	121·0
Napierville Junction Ry.—Grand Trunk railway, Ottawa division (diamond crossing)	142·4
" Lacolle	146·1
" Napierville	184·7
" St. Edouard	176·8
" La Tortue	133·5
" Delson	91·2
Canadian Pacific Railway—Delson	91·8
" Grand Trunk railway (diamond crossing at Delson)	92·1
Grand Trunk Railway—Laprairie	60·0
" Brosseau	59·4
" Montreal and Southern Counties (electric) railway, diamond crossing	63·5
" St. Lambert	74·3
" St. Hubert	89·7
" St. Bruno	80·0
" St. Bazile	61·3
" Beloeil	62·9
" Richelieu river; water, Nov. 3, 1915, 20·8; rail	65·7
" Otterburn Park	70·0
" St. Hilaire	83·9
" St. Hilaire East	100·0
" Ste. Madeleine	116·9
" Quebec, Montreal and Southern railway (diamond crossing),	113·7
" St. Hyacinthe	109·8
" Yamaska river; water, May 16, 1916, 63·7; rail	103·9
" Canadian Pacific railway, St. Guillaume branch (diamond crossing at Ste. Rosalie Junction)	110·5
" Ste. Rosalie	113·5
" Britannia Mills	220·9
" St. Liboire	289·3
" Upton	202·3
" Black river; water, May 29, 1916, 166·1; rail	202·1
" Actonvale	310·5
" Canadian Pacific railway, Drummondville branch (diamond crossing)	317·6
" Danby	437·3
" South Durham	607·4
" Lisgar	528·6
" Gore	534·8
" St. Francis river; water, June 19, 1916, 365·6; rail	422·5
" Richmond	391·1
" Corris	402·4
" Morse	408·0
" Windsor Mills	416·2
" Coney Island	421·6
" Titus	427·2
" St. Francis river; water, July 5, 1916, 411·1; rail	442·4
" Bromptonville	470·0
" Magog river; water, July 7, 1916, 462·4; rail	486·9
" Sherbrooke	484·9

RAIL ELEVATIONS, STE. ROSALIE JUNCTION TO FARNHAM, QUE.

(Elevations taken in 1916)

Canadian Pacific Railway—Grand Trunk railway (diamond crossing at Ste. Rosalie Junction)	110·5
" St. Hyacinthe	108·6
" St. Pie	131·4
" Black river; water, May 3, 1916, 109·0; rail	132·0
" Montreal and Southern Counties (electric) railway, diamond crossing	208·8
" Abbottsford	208·6
" Papineau	211·7
" Canrobert	234·8
" Yamaska river; water, May 6, 1916, 180·8; rail	212·1
" Central Vermont railway (diamond crossing at Farnham)	208·6

RAIL ELEVATIONS, CHAUDIERE TO RICHMOND, QUE.

(Elevations taken in 1916)

		FEET
Grand Trunk Railway—	Chaudiere	237·1
"	Craig Road	338·2
"	St. Agapit	409·3
"	Dosquet	448·0
"	Lyster	449·3
"	Bécancour river; water, Oct. 3, 1916, 429·5; rail	449·4
"	Ste. Julie	477·9
"	Plessisville	444·2
"	Princeville	528·5
"	Branch Nicolet river; water, Oct. 27, 1916, 475·4; rail	501·2
"	Victoriaville	433·4
"	Nicolet river; water, Oct. 21, 1916, 395·3; rail	422·5
"	Warwick	483·4
"	Kingsey	446·6
"	Southwest branch Nicolet river; water, Oct. 30, 1916, 365·0; rail	394·0
"	Danville	448·6
"	St. Cyr	484·3
"	Richmond	391·1

RAIL ELEVATIONS, MONTREAL LOOP LINE

(Elevations taken in 1917)

Grand Trunk Railway—	St. Lambert	74·3
"	Victoria bridge (highest point)	91·3
"	Point St. Charles	52·9
"	Lachine canal; water, 56·9; rail	65·8
"	St. Henri	60·2
Canadian Pacific Railway—	Montreal, Windsor street station	108·5
"	Atwater avenue subway	132·6
"	Westmount	151·7
"	Montreal West	158·1
"	North Junction	139·6
"	St. Luc Junction	156·2
"	Côte-des-Neiges	179·3
"	Outremont	206·2
"	Mile End	222·7
"	Angus	160·3
"	Hochelaga	77·2
"	Montreal, Place Viger station	58·1

RAIL ELEVATIONS, BRANTFORD TO LUCAN CROSSING, ONT.

(Elevations taken in 1916)

Grand Trunk Railway—	Brantford	705·9
"	Alford (Harrisburg branch)	717·6
"	Harrisburg	736·7
"	Branchton	895·3
"	Galt	876·1
"	Canadian Pacific railway, main line (overhead crossing) rail 943·9; G.T.R. rail	921·5
"	Preston	925·9
"	Galt, Preston & Hespeler (electric) railway, diamond crossing	949·7
"	Speed river; water, June 13, 1916, 935·7; rail	949·2
"	Hespeler	943·4
"	Gourock	1,059·6
"	Guelph Junction (diamond crossing)	1,075·9
"	Guelph	1,069·1
"	Mosborough	1,084·9
"	Breslau	1,025·1
"	Grand river; water, June 28, 1916, 962·4; rail	1,012·0
"	Kitchener	1,101·2
"	Waterloo (branch)	1,058·2
"	Petersburg	1,211·9
"	Baden	1,157·9
"	New Hamburg	1,128·0
"	Nith river; water, July 10, 1916, 1085·0; rail	1,126·2
"	Shakespeare	1,183·6
"	Stratford	1,192·7
"	St. Pauls	1,165·7
"	St. Marys Junction	1,083·0
"	St. Marys (branch)	1,055·3

RAIL ELEVATIONS, BRANTFORD TO LUCAN CROSSING, ONT.—*Concluded.*

(Elevations taken in 1916)

		FEET
Grand Trunk Railway—	North branch Thames river; water, July 27, 1916, 989·7; rail	1,042·2
"	Granton	1,034·2
"	Lucan	990·5
"	Grand Trunk railway, London-Wingham line (under crossing) rail 861·6; main line, rail	882·5
"	Lucan Crossing (station)	861·6

RAIL ELEVATIONS, GUELPH JUNCTION TO PALMERSTON, ONT.

(Elevations taken in 1916)

Grand Trunk Railway—	Guelph Junction (diamond crossing)	1075·9
"	Canadian Pacific railway, Guelph-Goderich line (diamond crossing)	1112·4
"	Marden	1131·5
"	Elora	1295·6
"	Grand river; water, Aug. 14, 1916, 1236·6; rail	1303·1
"	Fergus	1355·8
"	Canadian Pacific railway, Elora branch (diamond crossing)	1364·3
"	Alma	1438·6
"	Goldstone	1454·8
"	Conestoga river; water, Aug. 24, 1916, 1307·6; rail	1351·4
"	Drayton	1356·2
"	Moorefield	1349·7
"	Palmerston	1312·1

RAIL ELEVATIONS, FERGUS TO MELVILLE, ONT.

(Elevations taken in 1916)

Canadian Pacific Railway—	Fergus	1360·1
"	Grand Trunk railway, Harrisburg-Southampton line (diamond crossing)	1364·3
"	Spier	1394·5
"	Grand river; water, Sept. 2, 1916, 1351·0; rail	1372·4
"	Belwood	1419·5
"	Orton	1451·7
"	Hillsburgh	1418·6
"	Erin	1293·7
"	Cataract	1253·9
"	Alton	1315·9
"	Melville (Streetsville Junction line)	1329·0
"	Melville (Toronto-Owen Sound line)	1328·7

RAIL ELEVATIONS, PORT DALHOUSIE TO PORT COLBORNE, ONT.

	Lake Ontario; water, Sept. 28, 1916	245·6
Grand Trunk Railway—	Welland canal swing bridge; water, 317·9; rail	323·5
"	Merritton	397·4
"	Port Robinson	588·0
"	Welland	599·4
"	Welland Junction (diamond crossing)	579·5
"	Humberstone	589·0
"	Port Colborne (diamond crossing)	583·0
	Lake Erie; water, Oct. 5, 1916	571·3

RAIL ELEVATIONS, FRANZ TO PORT ARTHUR, ONT.

(Elevations taken in 1916)

Canadian Pacific Railway—	Algoma Central railway (diamond crossing at Franz)	1216·5
"	Williams	1179·2
"	Magpie lake; water, May 12, 1916, 1129·4; rail (on bridge)	1160·4
"	Swanson	1160·8
"	Grasett	1236·4
"	Ryerson	1382·5
"	Girdwood	1432·0
"	Tripoli	1411·7
"	Amyot	1379·9
"	Birch	1370·7
"	White river (mileage 119·5 from Chapleau); water, May 25, 1916, 1298.0; rail	1329·6

RAIL ELEVATIONS, FRANZ TO PORT ARTHUR, ONT.—*Continued.*

(Elevations taken in 1916)

		FEET
Canadian Pacific Railway—	O'Brien	1438·3
"	Depew	1317·5
	White river (mileage 129·1 from Chapleau); water, June 1, 1916, 1241·0; rail	1260·5
"	White river (mileage 129·6 from Chapleau); water, June 1, 1916, 1237·2; rail	1249·7
"	White River (station)	1223·2
"	Denison	1175·1
"	White river (mileage 12·2 from White River); water, June 12, 1916, 1136·3; rail	1146·8
"	Bremner	1148·5
"	Bremner river; water, June 14, 1916, 1121·7; rail	1132·4
"	King	1077·9
"	White river (mileage 24·6 from White River); water, June 15, 1916, 1069·9; rail	1079·0
"	Trudeau	1038·5
"	Struthers	1032·2
"	Cedar river (mileage 33·9 from White River); water, June 23, 1916, 1025·6; rail	1035·4
"	Hemlo	970·5
"	Pringle	880·1
"	Melgund	813·1
"	Black river; water, July 6, 1916, 756·2; rail	802·8
"	Pic river; rail on bridge	687·4
"	Heron Bay	707·8
"	Craigs	699·7
"	Peninsula	703·2
"	Angler	703·4
"	Coldwell	711·3
"	Neys	855·2
"	Little Pic river; rail on bridge	693·1
"	Middleton	687·9
"	Ripple	666·6
"	Steel	737·6
"	Steel river; water, July 25, 1916, 609·8; rail	674·2
"	Santoy	702·5
"	Jackfish	633·2
"	Noslo	693·6
"	Blacks	893·8
"	Black river; water, Aug. 15, 1916, 817·8; rail	888·0
"	Schreiber	992·9
"	Horn	863·1
"	Winston	762·4
"	Selim	718·3
"	Rossport	644·6
"	Pays Plat river; water (Lake Superior), Aug. 18, 1916, 602·1; rail	608·1
"	Pays Plat	620·2
"	Cavers	642·2
"	Gravel	618·8
"	Gravel river; Water (Lake Superior), Aug. 30, 1916, 602·1; rail	621·3
"	Gurney	608·3
"	Dublin	687·9
"	Kama	644·5
"	Ozone	627·3
"	Fire Hill	605·9
"	Ruby	691·4
"	Nipigon river; water, Sept. 13, 1916, 605·2; rail	685·5
"	Canadian Northern railway (under crossing) rail 619·2; C.P.R. rail	685·5
"	Nipigon	679·3
"	Red Rock	638·2
"	Sprucewood	690·1
"	Black Sturgeon river; water, Sept. 22, 1916, 612·6; rail	667·3
"	Coglin	669·3
"	Hurkett	606·8
"	Wolf river; water, Sept. 23, 1916, 608·8; rail	627·0
"	Dorion	677·1
"	Ouimet	740·5
"	Bowker	774·4
"	Pearl	845·5
"	Pearl river; rail on bridge	848·7
"	Loon	1048·4
"	Mackenzie river; water, Oct. 3, 1916, 985·4; rail	996·9
"	Beck	957·1
"	Mackenzie	913·7
"	Navilus	762·7

RAIL ELEVATIONS, FRANZ TO PORT ARTHUR, ONT.—*Concluded.*

(Elevations taken in 1916)

		FEET
Canadian Pacific Railway—	Current River (station)	639·6
"	Current river; water, Oct. 14, 1916, 625·3; rail	638·0
"	Port Arthur	613·7
"	Lake Superior; water, Oct. 17, 1916	602·0

RAIL ELEVATIONS, JASPER, ALTA. TO LOOS, B.C.

(Elevations taken in 1916 and 1917)

Grand Trunk Pacific Ry.—	Jasper	3469·7
"	Miette river (mileage 1035·2 from Winnipeg); water, Aug. 15, 1916, 3555·9; rail	3580·5
"	Geikie	3588·4
"	Miette river (mileage 1038·8 from Winnipeg); water, Aug. 17, 1916, 3613·5; rail	3625·2
"	Miette river (mileage 1044·4 from Winnipeg); water, Aug. 18, 1916, 3704·0; rail	3719·3
"	Interprovincial boundary, Alberta-British Columbia	3722·0
"	Yellowhead	3717·1
"	Lucerne	3639·8
"	Alpland	3539·7
"	Grant Brook	3471·3
"	Moose river; water, Aug. 29, 1916; 3416·9; rail	3431·8
"	Rainbow	3399·8
"	Resplendent	3404·4
"	Fraser river; water, Aug. 30, 1916, 3360·9; rail	3400·4
"	Mount Robson	3115·0
"	Swiftwater	2827·2
"	Albreda	2655·3
"	McLennan river; water, Sept. 11, 1916, 2409·7; rail	2449·7
"	Tête Jaune	2402·5
"	Shere	2418·8
"	Croydon	2525·1
"	Dunster	2568·2
"	Raush Valley	2452·5
"	Raushuswap river; water, Sept. 27, 1916, 2329·8; rail	2420·9
"	Eddy	2363·2
"	McBride	2368·4
"	Legrand	2314·9
"	Rider	2237·2
"	Rooney	2198·4
"	Loos	2162·3

RAIL ELEVATIONS, ABBOTSFORD TO RESPLENDENT AND RAINBOW, B.C.

(Elevations taken in 1915, 1916 and 1917)

Canadian Pacific Railway—	Abbotsford	87·8
"	British Columbia Electric railway (diamond crossing)	24·1
"	Clayburn	21·6
"	Matsqui	23·9
"	Canadian Northern railway, main line (diamond crossing)	23·1
Canadian Northern Railway—	Matsqui	21·7
"	Sumas	34·3
"	Arnold	28·9
"	British Columbia Electric railway (diamond crossing near Chilliwack)	29·3
"	Rosedale	51·7
"	Cheam View	99·8
"	St. Elmo	94·2
"	Kettle Valley railway (diamond crossing near Hope)	162·3
"	Coquihalla river; water, Oct. 15, 1915, 150·0; rail	163·4
"	Yale	218·2
"	Chapman	357·4
"	Anderson river; water, May 13, 1916, 324·3; rail	436·7
"	Boston Bar	452·7
"	Falls Creek	605·9
"	Canadian Pacific railway, main line (under crossing) rail 541·8; C.N.R. rail	602·9
"	Fraser river (mileage 103·9 from Kamloops Junction); water, May 29, 1916, 432; rail	602·9
"	Fraser river (mileage 98·3 from Kamloops Junction); water, May 29, 1916, 456·3; rail	562·6
"	Lytton	565·3

RAIL ELEVATIONS, ABBOTSFORD TO RESPLENDENT AND RAINBOW, B.C.—*Concluded.*

(Elevations taken in 1915, 1916 and 1917)

		FEET
Canadian Northern Railway	Thompson river (mileage 97·5 from (Kamloops Junction); water May 30, 1916, 462·0; rail	566·3
"	Seddell	699·3
"	Spence Bridge	741·8
"	Thompson river (mileage 59·7 from Kamloops Junction); water, June 21, 1916, 862·7; rail	898·5
"	Basque	901·8
"	Thompson river (mileage 55·0 from Kamloops Junction); water, June 22, 1916, 897·0; rail	928·0
"	Ashcroft	992·5
"	Thompson river (mileage 47·3 from Kamloops Junction); water, June 23, 1916, 971·2; rail	991·9
"	Thompson river (mileage 45·8 from Kamloops Junction); water, June 24, 1916, 979·7; rail	1008·0
"	McAbee	1032·9
"	Thompson river (mileage 34·1 from Kamloops Junction); water, July 3, 1917, 1060·7; rail	1085·2
"	Walhachin	1085·5
"	Thompson river (mileage 28·9 from Kamloops Junction); water, July 4, 1916, 1104·2; rail	1132·2
"	Savona	1174·1
"	Copper Creek	1171·8
"	Tranquille	1183·4
"	Mytton	1152·8
"	North Thompson river; water, July 18, 1916, 1125·2; rail	1155·1
"	Kamloops Junction	1153·2
"	St. Paul	1176·4
"	Vinsulla	1185·5
"	McLure	1187·8
"	Louis Creek (station)	1236·1
"	Louis creek; water, May 7, 1917, 1233·5; rail	1242·3
"	Barrière	1247·9
"	Barrière river; water, May 7, 1917, 1228·3; rail	1246·0
"	Chinook Cove	1252·1
"	Chu Chua	1275·7
"	Mount Olie	1267·2
"	Boulder	1286·4
"	Blackpool	1302·7
"	Clearwater	1329·4
"	Birch Island	1385·8
"	North Thompson river, Birch Island bridge; water (southerly channel) May 30, 1917, 1389·6; rail	1405·7
	water (northerly channel) May 30, 1917, 1396·5; rail	1425·9
"	Vavenby	1537·6
"	Irvine	1633·4
"	North Thompson river; water, June 4, 1917, 1612·3; rail	1681·1
"	McMurphy	1785·7
"	North Thompson river; water, June 12, 1917, 1851·7; rail	1868·7
"	Avola	1896·7
"	Messiter	2079·4
"	Wolfenden	2169·4
"	Trout Creek	2189·9
"	Blue River (station)	2236·9
"	Blue river; water, July 5, 1917, 2211·2; rail	2228·9
"	Thunder river; water, July 6, 1917, 2248·0; rail	2259·2
"	NorthThompson river; water, July 10, 1917, 2244·3; rail	2260·1
"	Thunder River (station	2258·7
"	Pyramid	2304·3
"	Lemprière	2440·7
"	Clemina	2744·8
"	Albreda	2866·1
"	Canoe River	2723·3
"	Swift Creek	2602·2
"	Jackman	2818·3
"	Morey	3059·3
"	Mount Robson	3258·3
"	Resplendent	3417·9
"	Fraser river; water, Aug. 13, 1917, 3386·4; rail	3408·1
"	Rainbow	3400·6

RAIL ELEVATIONS, REVELSTOKE TO KAMLOOPS, B.C.

(Elevations taken in 1916)

		FEET
Canadian Pacific Railway—	Revelstoke	1496·7
"	Columbia river; water, Aug. 1, 1916, 1438; rail	1479·0
"	Three Valley	1638·8
"	Eagle river mileage 15·44 from Revelstoke); water, Aug. 8, 1916, 1616·3; rail	1625·2
"	Eagle river (mileage 17·9 from Revelstoke); water, Aug. 8, 1916, 1488·7; rail	1503·0
"	Crazy creek (mileage 24·2 from Revelstoke); water, Aug. 9, 1916, 1272·8; rail	1281·6
"	Taft	1281·5
"	Eagle river (mileage 24·8 from Revelstoke); water, Aug. 9, 1916, 1255·4; rail	1266·5
"	Eagle river (mileage 26·0 from Revelstoke); water, Aug. 10, 1916, 1241·6; rail	1253·0
"	North fork, Eagle river (mileage 26·5 from Revelstoke); water, Aug. 10, 1916, 1243·3; rail	1256·1
"	Craigellachie	1226·9
"	Eagle river (mileage 31·5 from Revelstoke); water, Aug. 11, 1916, 1196·5; rail	1214·4
"	Malakwa	1215·9
"	Eagle river (mileage 33·0 from Revelstoke); water, Aug. 12, 1916, 1189·9; rail	1206·5
"	Eagle river (mileage 37·25 from Revelstoke); water, Aug. 19, 1916, 1159·8; rail	1179·5
"	Eagle river (mileage 40·6 from Revelstoke); water, Aug. 19, 1916, 1150·0; rail	1167·2
"	Solsqua	1164·5
"	Eagle river (mileage 44·0 from Revelstoke); water, Aug. 21, 1916, 1138·5; rail	1158·2
"	Sicamous narrows; water Aug. 21, 1916, 1137·5; rail	1156·0
"	Sicamous	1155·4
"	Canoe	1153·5
"	Salmon Arm	1159·6
"	Salmon river; water, Sept. 1, 1916, 1138·8; rail	1151·3
"	Tappen	1159·5
"	Carlin	1423·1
"	Notch Hill	1692·4
"	Elson	1485·7
"	Chase	1184·6
"	Shuswap	1154·9
"	Pritchard	1152·2
"	Duck	1156·2
"	Kamloops	1160·7

INDEX

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED.

Note.—Under "Year of Publication,"
1912 refers to Vol. I, No. 2*, "Publications of the Dominion Observatory."
1913 " Vol. I, No. 3, "
1914 " Vol. I, No. 8, "
1915 " Vol. II, No. 1, "
1916 " Vol. III, No. 6, "
1917 " Vol. III, No. 8, "
1918 " refers to the present publication.

Place	B.M. Number	Year of Publication	Description	Elevation
	A		Page	Page
Abbotsford, B.C.	28–J	1918	23	43
Abbottsford, Que.	620–B	1918	11	33
Abercorn, Que.	54	1917	282	318
Actonvale, Que.	630–B	1918	9	32
Adamsville, Que.	59	1917	281	317
Ailsa Craig, Ont.	343	1914	220	236
Alameda, Sask.	57–C	1913	69	83
Albert Canyon, B.C.	303–C	1917	270	310
Alcove, Que.	472	1914	218	234
Aldergrove, B.C.	24–J	1916	170	191
Algoma, Ont.	602	1916	156	181
Alix, Alta.	61–F, 62–F	1916	165	187
Allenford, Ont.	292	1913	60	83
Alliston, Ont.	382, 383	1913	64	86
Almonte, Ont.	64–G, 65–G, 66–G	1917	250	293
Alton, Ont.	131–F	1918	17	37
Amherst, N.S.	545–B *to* 548–B	1916	146	173
Andover, N.B.	40–B	1917	277	314
Antigonish, N.S.	172–B, 173–B	1913	47	74
Apohaqui, N.B.	115–B	1913	44	73
Appin, Ont.	240	1913	56	81
Apple Hill, Ont.	100	1917	285	320
Ardendale, Ont.	165–G	1917	256	295
Adrossan, Alta.	55–H	1916	163	186
Argyle, N.S.	457–B	1915	13	30
Arnprior, Ont.	73–G, 74–G, 75–G	1917	250	293
Aroostook, N.B.	41–B	1917	277	314
Artland, Sask.	28–H	1915	20	34
Ashcroft, B.C.	74–J	1918	26	42
Asquith, Sask.	5–H	1915	19	34
Athalmer, B.C.	153–D	1917	265	305
Atwood, Ont.	309	1913	61	83
Auburn, N.S.	487–B	1916	148	175
Avondale, N.S.	167–B	1913	47	74
Avonmore, Ont.	103	1917	285	320
Ayers Cliff, Que.	28–A–2, 29	1913	48	75
Aylesbury, Sask.	14–D	1913	72	90
Azilda, Ont.	457	1914	225	238
	B			
Baden, Ont.	101–F	1918	15	36
Baker Brook, N.B.	264–B	1917	247	290
Bala, Ont.	408	1913	66	86
Banff, Alta.	240–C, 241–C	1916	167	188
Barons, Alta.	76–D, 77–D	1915	25	38
Barrington, N.S.	444–B	1915	12	29
Barrington Passage, N.S.	446–B	1915	12	29
Barrys Bay, Ont.	523	1915	16	32
Bashaw, Alta.	65–F	1916	165	187

*The bench-mark numbers in this publication (Yukon levelling) follow a series independent of those in the later publications; in order to distinguish them they are printed in italics in the "B.M. Number" column.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Bath, N.B	35–B	1917	276	314
Bayfield, N.S	177–B	1913	48	75
Beamsville, Ont	204	1913	63	85
Beaudette, Minn	16–E	1914	226	239
Beavermouth, B.C	284–C	1917	269	309
Bedford, Que	66	1917	282	318
Bedford, N.S	506–B	1916	144	171
Beecher Falls, Vt	562–B	1916	153	180
Beeton, Ont	379	1913	64	86
Beiseker, Alta	48–F	1916	164	187
Belgrave, Ont	316	1913	61	83
Bellamy, Ont	101–G	1917	252	298
Belle River, Ont	252	1913	57	81
Belleville, N.S	459–B	1915	13	30
Belleville, Ont	156 *to* 157–A–2	1917	288	322
Beloeil, Que	606–B	1918	9	32
Bennett, B.C	*32–R*	1912	23	23
Benton, N.B	18–B	1917	276	313
Berwick, N.S	488–B	1916	148	175
Bethume, Sask	9–D	1913	71	90
Bienfait, Sask	61–C	1913	69	88
Biggar, Sask	12–H	1915	20	34
Blackie, Alta	63–D	1915	26	38
Bladworth, Sask	19–D	1914	227	240
Blaine, Wash	19–J	1916	169	190
Blairmore, Alta	103–D	1917	262	304
Blind River, Ont	604, 605	1916	156	181
Bloomfield, N.B	111–B	1913	44	73
Blue River, B.C	124–J, 125–J	1918	28	43
Bluevale, Ont	313	1913	61	83
Blyth, Ont	317	1913	61	83
Boharm, Sask	106–C	1914	229	241
Boiestown, N.B	33–C	1916	151	178
Boissevain, Man	31–C, 32–C	1913	67	87
Bolton, Ont	260	1913	58	82, 86
Bothwell, Ont	243	1913	57	81
Boundary Creek, N.B	128–B	1913	45	73
Bow Island, Alta	178–C, 179–C	1915	23	35
Bowmanville, Ont	177	1913	54	79
Braeburn, Y.T	*57*	1912	27	27
Brant, Alta	65–D	1915	26	38
Brantford, Ont	219, 220	1913	55	80
Breslau, Ont	94–F	1918	14	36
Bridgeburg, Ont	215–A	1913	64	85
Bridgewater, N.S	409–B *to* 411–B	1915	10	28
Brierly Brook, N.S	170–B	1913	47	74
Brighton, Ont	163	1917	288	322
Bristol, N.B	34–B	1917	276	314
Britannia Mills, Que	625–B	1918	9	32
Brockville, Ont	123, 124	1917	286	321
"	105–G, 106–G	1917	252	298
Brome, Que	50	1917	282	318
Bromptonville, Que	648–B	1918	10	33
Brookport, Que	60	1917	281	317
Bruce, Alta	45–H	1916	162	186
Bruce Mines, Ont	619	1916	156	182
Brucefield, Ont	329	1913	62	84
Brunswick, N.B	6–B	1917	275	313
Brussels, Ont	312	1913	61	83
Bull River, B.C	135–D	1917	264	305
Burdett, Alta	180–C, 181–C	1915	23	35, 36
Burlington Jct., Ont	196	1913	55	80
Bury, Que	13–A–2	1913	49	76
	C			
Calabogie, Ont	139–G	1917	254	299
Calais, Maine	1–B	1917	275	313
Caldwell, Ont	512	1915	16	32
Caledon, Ont	265	1913	58	82
"	265	1918	17	37

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Calgary, Alta	50–D, 51–D, 52–D	1915	27	39
"	39–F	1916	163	187
"	217–C, 218–C	1916	166	188
Cambridge, N.S	490–B	1916	148	175
Campbellton, N.B	25–G, 26–G	1916	151	177
Camrose, Alta	70–F, 71–F	1916	165	187
Canmore, Alta	235–C	1916	167	188
Canrobert, Que	622–B	1918	11	33
Canterbury, N.B	16–B	1917	276	313
Capelton, Que	26	1913	48	75
Cap St. Ignace, Que	567–B	1917	247	291
Cariboo, Y.T	*18–R*	1912	24	24
Carievale, Sask	49–C	1913	68	88
Carleton Place, Ont	60–G, 61–G, 62–G	1917	249, 250	293
Carmangay, Alta	73–D, 74–D	1915	25	38
Carnduff, Sask	50–C	1913	68	88
Caron, Sask	108–C	1914	229	241
Cartwright, Man	20–C	1913	67	87
Cascades, Que	467	1914	218	234
Cataract, Ont	130–F	1918	16	37
Chamberlain, Sask	12–D	1913	72	90
Champion, Alta	71–D	1915	26	38
Chaplin, Sask	113–C	1914	229	241
Chase, B.C	342–C	1918	31	45
Chatham, Ont	246–A, 247, 247–A	1913	57	81
"	373, 247	1914	222	236
Chatham, N.B	49–G	1916	152	178
Chatsworth, Ont	283	1913	59	82
Chaudiere, Que	MCLXXII	1918	‡	34
Chauvin, Alta	30–H	1915	21	34
Chelsea, Que	464	1914	218	234
Chesley, Ont	295, 296	1913	60	83
Chester, N.S	401–B	1915	10	28
Chesterville, Ont	107	1917	285	320
Chilliwack, B.C	34–J, 35–J	1918	24	42
Chin, Alta	191–C	1915	23	36
Chipman, N.B	352–B	1914	216	233
Chu Chua, B.C	98–J	1918	27	43
Clarkson, Ont	192	1913	55	80
Clarksville, N.S	520–B, 521–B	1916	145	171
Clayburn, B.C	29–J	1918	24	42
Clifton, N.S	531–B	1916	145	172
Clinton, Ont	320, 321	1913	62	83
Cloverdale, B.C	20–J, 21–J	1916	169	191
Coaticook, Que	14, 15, 16	1917	283	319
Coblenz, Sask	17–H	1915	20	34
Cobourg, Ont	171	1913	53	79
Cochrane, Alta	222–C, 223–C	1916	166	188
Colborne, Ont	166	1917	288	322
Coldbrook, N.S	491–B	1916	148	175
Coldwater, Ont	399–A	1913	65	86
Coleman, Alta	105–D	1917	262	304
Collins Bay, Ont	144	1917	287	321
Compton, Que	10	1917	283	319
Condie, Sask	5–D	1913	71	90
Conn Mills, N.S	139–B	1913	46	74
Cooking Lake, Alta	53–H	1916	163	186
Cookshire, Que	10–A–3, 11–A	1913	49	76
Copetown, Ont	216–A	1913	55	80
Corbetton, Ont	273	1913	59	82
Corbyville, Ont	185–G	1917	257	301
Cornwall, Ont	489, 490, 491	1914	219	235
Corunna, Ont	361	1914	221	236
Coteau Jct., Que	90	1917	284	320
Côte-des-Neiges, Que	815, 816, 817	1918	13	35
Courtright, Ont	363	1914	222	236
Coutts, Alta	216–C†	1915	25	37
Cowley, Alta	97–D	1917	262	304
Craighurst, Ont	392	1913	65	86

‡Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Craik, Sask	16–D	1913	72	90
Cranbrook, B.C	172–D *to* 174–D	1917	266	307
Creston, B.C	195–D, 196–D	1917	268	307
Crooksston, Ont	179–G	1917	257	296
Crowsnest, B.C	109–D	1917	263	304
Crysler, Ont	496	1914	220	235
Crystal City, Man	16–C	1913	67	87
	D			
Dalhousie Mills, Ont	95	1917	285	320
Danby, Que	633–B	1918	10	33
Danville, Que	679–B	1918	12	43
Dauntless, Alta	171–C	1915	22	35
Davidson, Sask	18–D	1914	227	240
Dawson, Y.T	*223, 224*	1912	34	34
Dean Lake, Ont	609	1916	156	182
Debec, N.B	20–B	1917	276	313
Delburne, Alta	59–F	1916	165	187
Deloraine, Man	36–C	1913	68	88
Delson, Que	593–B, 594–B	1918	8	32
Denfield, Ont	338	1913	62	84
Denmark, N.S	149–B	1913	46	74
Depot Harbour, Ont	566, 567	1915	13	31
Derby Jct., N.B	47–G–2	1916	152	178
Derby Line, Vt	33–A	1913	49	75
Desbarats, Ont	622	1916	157	182
Devlin, Ont	27–E	1914	226	239
DeWinton, Alta	57–D	1915	26	38
Dinant, Alta	73–F	1916	165	187
Disley, Sask	8–D	1913	71	90
Doaktown, N.B	37–G	1916	151	178
Dobbinton, Ont	294	1913	60	83
Dorchester, N.B	DCCCLXXXIX, *etc.*	1916	‡	174
Dorenlee, Alta	66–F	1916	165	187
Dosquet, Que	657–B	1918	11	34
Drayton, Ont	123–F	1918	16	37
Dresden, Ont	370	1914	222	236
Drinkwater, Sask	91–C	1913	70	89
Duck, B.C	348–C	1918	31	45
Duck Lake, Sask	42–D	1914	228	240
Dundalk, Ont	274	1913	59	82
Dundas, Ont	215	1913	55	80
Dundurn, Sask	25–D	1914	227	240
Dunmore, Alta	165–C	1915	22	35
	E			
Eastman, Que	44	1917	281	317
East Pubnico, N.S	453–B	1915	13	29
Eastray, Que	44	1917	281	317
Eastwood, Ont	225	1913	55	80
Echo Bay, Ont	626	1916	157	182
Edgerton, Alta	33–H	1915	21	34
Edmonton, Alta	58–H *to* 61–H	1916	163	186
Edmundston, N.B	58–B, 59–B, 60–B	1917	278	314
Edson, Alta	81–H, 82–H	1917	272	311
Eganville, Ont	514	1915	16	32
Elmwood, Ont	297	1913	60	83
Elora, Ont	117–F, 118–F	1918	16	37
Elva, Man	44–C	1913	68	88
Embrun, Ont	498	1914	220	235
Emerson, Man	3–C	1913	66	87
Emo, Ont	23–E, 24–E	1914	226	239
Enlaugra, Que	51	1917	282	318
Ensign, Alta	66–D	1915	26	38
Erin, Ont	129–F	1918	16	37
Ernestown, Ont	146	1917	287	321

† Also bench-mark in international boundary monument. ‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Ernfold, Sask.	115-C	1914	229	241
Estevan, Sask.	62-C, 63-C	1913	69	88
Eureka, Y.T.	*187*	1912	33	33
Exeter, Ont.	332, 333	1913	62	84
	F			
Fairville, N.B.	96-B	1917	280	316
Farnham, Que.	62	1917	281	317
"	63, 64	1917	282	318
"	623-B, 62	1918	11	33
Fergus, Ont.	119-F, 120-F	1918	16	37
Ferintosh, Alta.	67-F	1916	165	187
Fernie, B.C.	121-D *to* 123-D	1917	263	305
Field, B.C.	260-C	1916	168	189
Finch, Ont.	105	1917	285	320
"	495	1914	219	235
Findlater, Sask.	11-D	1913	72	90
Flesherton, Ont.	277	1913	59	82
Forest, Ont.	351	1914	221	236
Fort Erie, Ont.	215-A	1913	64	85
Fort Frances, Ont.	29-E, 30-E	1914	226	239
Fort William, Ont.	90-E *to* 92-E	1916	161	184
Foster, Que.	47	1917	281	317
Frank, Alta.	102-D	1917	262	304
Franz, Ont.	708	1917	261	303
French Village, N.S.	393-B	1915	9	28
Frobisher, Sask.	58-C	1913	69	88
Fulford, Que.	56	1917	281	317
	G			
Gainsborough, Sask.	47-C	1913	68	88
Galt, Ont.	81-F *to* 82-F-2	1918	14	36
Girvin, Sask.	17-D	1913	72	90
Glacier, B.C.	294-C	1917	270	309
Glacier, Y.T.	*266*	1912	36	36
Glencoe, Ont.	241, 241-A	1913	56	81
Glen Ewen, Sask.	52-C	1913	68	88
Glentay, Ont.	117-G	1917	253	295
Goderich, Ont.	325, 326, 327	1913	62	83, 84
Godfrey, Ont.	150-G	1917	255	300
Golden, B.C.	273-C	1917	269	309
Golden Lake, Ont.	515	1915	16	32
Goodlands, Man.	38-C	1913	68	88
Gracefield, Que.	484	1914	219	234
Graceton, Minn.	14-E	1914	226	239
Grafton, Ont.	168	1913	53	79
Grainger, Alta.	50-F	1916	164	187
Grand Coulee, Sask.	101-C	1913	71	89
Grand Falls, N.B.	46-B	1917	277	314
Grand Ligne, Que.	78	1917	280	317
Grand Pre, N.S.	498-B	1916	149	175
Grandora, Sask.	3-H	1915	19	34
Grassy Lake, Alta.	182-C, 183-C	1915	23	36
Green River, N.B.	54-B	1917	277	314
Green Valley, Ont.	97	1917	285	320
Gretna, Man.	4-C	1913	66	87
Grimsby, Ont.	203	1913	63	85
Guelph, Ont.	90-F *to* 92-F	1918	14	36
Guelph Jct., Ont.	88-F, 89-F	1918	14	36
Gull Lake, Sask.	136-C	1914	230	241
	H			
Hague, Sask.	38-D	1914	228	240
Halbrite, Sask.	73-C	1913	69	89
Halifax, N.S.	386-B, 387-B	1915	9	28
"	386-B, 387-B	1916	144	171
Hallock, Minn.	2-C	1913	66	87

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Hamilton, Ont.	198, 199, 200	1913	63	85
Hampton, N.B.	109–B	1913	44	73
Hanley, Sask.	23–D	1914	227	240
Hanover, Ont.	298, 299	1913	60	83
Hantsport, N.S.	500–B	1916	149	176
Harlaka Jct., Que.	219–B	1913	52	77
Harrisburg, Ont.	77–F	1918	14	36
Harriston, Ont.	303, 304	1913	61	83
Harrowsmith, Ont.	154–G	1917	255	300
Hartland, N.B.	31–B	1917	276	313
Hatton, Sask.	151–C	1915	21	35
Hawthorne, Ont.	502	1914	220	235
Heath, Alta.	34–H	1915	21	34
Henfryn, Ont.	310	1913	61	83
Herbert, Sask.	118–C	1914	230	241
Heron Bay, Ont.	742, 742–A	1918	19	39
Hespeler, Ont.	86–F	1918	14	36
Hillhurst, Que.	13	1917	283	319
Hillsburgh, Ont.	128–F	1918	16	37
Holden, Alta.	46–H	1916	163	186
Holland Centre, Ont.	281	1913	59	82
Holmesville, Ont.	322	1913	62	83
Holmfield, Man.	22–C	1913	67	87
Hope, B.C.	42–J, 43–J	1918	24	42
Howick Jct., Que.	87	1917	284	320
Hubbards, N.S.	397–B	1915	9	28
Hull, Que.	459, 460	1914	217	234
Humes, Y.T.	*132*	1912	31	31
Huntingdon, B.C.	26–J, 27–J	1916	170	191
Hyde Park Jct., Ont.	341	1913	63	84
	I			
Iberville, Que.	74	1917	280	317
Ilderton, Ont.	339	1913	63	84
Indian River, Y.T.	*205*	1912	33	33
Ingersoll, Ont.	229, 230	1913	56	80
Inkerman, Ont.	110	1917	285	320
Irma, Alta.	39–H	1916	162	185
Irvine, Alta.	159–C, 160–C	1915	22	35
Ivanhoe, Ont.	179–G	1917	257	296
	J			
Jackfish, Ont.	757	1918	19	39
Jaffray, B.C.	131–D, 132–D	1917	264	305
James River, N.S.	169–B	1913	47	74
Jasper, Alta.	104–H	1917	274	312
Jasper, Ont.	97–G	1917	252	298
Jeannette, Ont.	249–A	1913	57	81
Jordan, Ont.	205	1913	63	85
Juniata, Sask.	6–H	1915	19	34
	K			
Kakabeka Falls, Ont.	85–E	1916	161	184
Kamloops, B.C.	353–C *to* 355–C	1918	31	45
Kamloops Jct., B.C.	87–J	1918	26	43
Kazabazua, Que.	479	1914	218	234
Kearney, Ont.	552	1915	14	31
Keewatin, Ont.	34–F	1915	19	33
Kempton, Ont.	113	1917	286	320
Kemptville, Ont.	113–A	1913	52	78
Kenaston, Sask.	21–D	1914	227	240
Kennetcook, N.S.	523–B, 524–B	1916	145	171
Kenora, Ont.	36–F, 37–F, 38–F	1915	19	33
Kentville, N.S.	492–B *to* 494–B	1916	148	175
Kilburn, N.B.	37–B	1917	277	314
Killaloe, Ont.	518,519	1915	16	32
Killarney, Man.	25–C	1913	67	87

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Kingsey, Que.	677–B	1918	12	44
Kingston, N.S.	486–B	1916	148	175
Kingston, Ont.	139, 141, 141–A, 142	1917	287	321
Kipp, Alta.	81–D	1915	25	38
Kippen, Ont.	330	1913	62	84
Kirkcaldy, Alta.	70–D	1915	26	38
Kirk Ferry, Que.	465, 466	1914	218	234
Kitchener, Ont.	95–F *to* 97–F	1918	15	36
Kleinburg, Ont.	258	1913	58	82
Knowlton, Que.	49	1917	282	318
Komoka, Ont.	237–A	1913	56	80
Kootenay Landing, B.C.	204–D, 205–D	1917	268	308
	L			
Lac Baker, N.B.	267–B	1917	247	290
Lacolle, Que.	583–B	1918	8	32
Lake Louise, Alta.	248–C, 249–C	1916	167	189
Landis, Sask.	16–H	1915	20	34
Lansdowne, Ont.	130, 131	1917	286	321
Laprairie, Que.	596–B	1918	8	32
Lavant, Ont.	132–G	1917	254	299
Leckford, Sask.	41–D	1914	228	240
Leney, Sask.	8–H	1915	19	34
Lennoxville, Que.	6	1917	283	319
Lepreau, N.B.	89–B	1917	279	316
Lethbridge, Alta.	196–C *to* 200–C	1915	24	36
" "	83–D	1915	25	38
Levis, Que.	221–B, 222–B	1913	52	77
"	222–B	1916	153	179
L'Islet, Que.	568–B	1917	248	291
Listowel, Ont.	307 308	1913	61	83
Little River, Y.T.	*34*	1912	26	26
Liverpool, N.S.	418–B, 419–B, 420–B	1915	11	29
Londesborough, Ont.	318	1913	61	83
London, Ont.	235, 236	1913	56	80
Londonderry, N.S.	CMLXXIX	1916	‡	172
Longwood, Ont.	239–A	1913	56	81
Lousana, Alta.	58–F	1916	165	187
Low, Que.	476	1914	218	234
Lower Argyle, N.S.	455–B	1915	13	30
Lower East Pubnico, N.S.	452–B	1915	12	29
Lucan, Ont.	114–F	1918	15	36
Lucan Crossing, Ont.	337	1913	62	84
" "	337	1918	15	36
Lucerne, B.C.	111–H	1918	22	41
Lumsden, Sask.	7–D	1913	71	90
Lyn, Ont.	125	1917	286	321
Lynden, Ont.	217	1913	55	80
Lyon Brook, N.S.	156–B	1913	47	74
Lyster, Que.	660–B	1918	11	34
Lytton, B.C.	62–J, 63–J	1918	25	42
	M			
Maccan, N.S.	CMXVI.	1916	‡	173
Macleod, Alta.	87–D, 88–D	1917	262	304
Macoun, Sask.	69–C	1913	69	89
Madawaska, Ont.	530, 531	1915	15	32
Madoc Jct., Ont.	182–G	1917	257	301
Magog, Que.	40, 41, 41–A	1917	281	317
Maitland, Ont.	121	1917	286	320
Malagash, N.S.	144–B	1913	46	74
Mallorytown, Ont.	128	1917	286	321
Manitou, Man.	11C, 12–C	1913	66	87
Maple Creek, Sask.	145–C, 146–C	1914	231	241
Markdale, Ont.	279	1913	59	82
Marysville, Ont.	152	1917	288	321
Massawippi, Que.	28–A	1913	48	75

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Massey, Ont.	590	1916	155	181
Mather, Man.	17–C	1913	67	87
Matsqui, B.C.	30–J	1918	24	42
McAdam, N.B.	11–B	1917	275	313
McBride, B.C.	131–H	1918	23	41
McGivney Jct., N.B.	333–B	1914	215	233
Meadowville, N.S.	153–B	1913	46	74
Medicine Hat, Alta.	167–C, 168–C, 169–C	1915	22	35
Medora, Man.	40–C	1913	68	88
Medway, N.S.	415–B	1915	10	28
Megantic, Que.	21–A–2, 22–A	1913	50	76
Melancthon, Ont.	271–A, 272	1913	59	82
Melita, Man.	42–C, 43–C	1913	68	88
Melville, Ont.	132–F	1918	17	37
Memramcook, N.B.	549–B	1916	146	174
Merigomish, N.S.	164–B	1913	47	74
Merrickville, Ont.	84–G	1917	251	295
Merritton, Ont.	209	1913	63	85
Michel, B.C.	114–D	1917	263	304
Michipicoten, Ont.	698	1917	261	303
Midale, Sask.	71–C	1913	69	89
Middleton, N.S.	482–B, 483–B	1916	148	175
Midhurst, Ont.	390	1913	65	86
Midnapore, Alta.	54–D	1915	27	39
Milan, Que.	18–A–2	1913	50	76
Milestone, Sask.	85–C	1913	70	89
Milk River, Alta.	213–C, 214–C	1915	25	37
Millerton, N.B.	47–G	1916	152	178
Mine Centre, Ont.	42–E	1916	158	183
Minto, Y.T.	*106*	1912	30	30
Mirror, Alta.	63–F	1916	165	187
Mission, B.C.	30–J	1918	24	42
Molson, Man.	10–F	1915	17	33
Monarch, Alta.	84–D	1917	261	304
Monckland, Ont.	102	1917	285	320
Moncton, N.B.	132–B, 133–B, 134–B	1913	45	73
"	373–B, 374–B, 132–B	1914	217	233
"	132–B	1916	146	174
Monk, Que.	385–B	1917	245	289
Montague, Y.T.	*69*	1912	28	28
Mont Carmel, Que.	28–G	1917	248	292
Montmagny, Que.	566–B	1917	247	291
Montreal, Que.	807 *to* 825	1918	13, 14	35
Montreal West, Que.	811 *to* 813	1918	13	35
Mooretown, Ont.	362	1914	221	236
Moosejaw, Sask.	94–C, 95–C, 96–C	1913	71	89
"	103–C	1914	229	241
Morden, Man.	7–C, 8–C	1913	66	87
Morse, Sask.	116–C, 117–C	1914	229	241
Mortlach, Sask.	110–C	1914	229	241
Mountain, Ont.	111	1917	285	320
Moyie, B.C.	181–D	1917	267	307
Mulgrave, N.S.	185–B	1913	48	75
Muniac, N.B.	37–B	1917	277	314
Murrayville, B.C.	23–J	1916	170	191
Musquash, N.B.	91–B, 92–B	1917	279	316
Mystic, Que.	65	1917	282	318
	N			
Nairn, Ont.	579, 580	1916	154	181
Napadogan, N.B.	323–B, 324–B	1914	215	232
Napanee, Ont.	149 *to* 150–A–2	1917	287	321
Napierville, Que.	586–B, 587–B	1918	8	32
Napinka, Man.	41–C	1913	68	88
Nappan, N.S.	CMXIX	1916	‡	173
Nauwigewauk, N.B.	107–B	1913	44	73
Nelson Jct., N.B.	47–G–2	1916	152	178

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Newbury, Ont.	242	1913	56	81
Newcastle, Ont.	176	1913	53	79
New Dayton, Alta.	206–C, 207–C	1915	24	36
New Germany, N.S.	469–B–2	1916	147	175
New Glasgow, N.S.	160–B	1913	47	74
New Hamburg, Ont.	102–F, 103–F	1918	15	36
New Norway, Alta.	68–F	1916	165	187
New Westminster, B.C.	9–J *to* 13–J	1916	169	190
Nictaux, N.S.	480–B	1916	148	175
Ninga, Man.	29–C	1913	67	87
Nipigon, Ont.	785	1918	21	40
Nobleford, Alta.	79–D	1915	25	38
Nordenskiöld, Y.T.	47	1912	27	27
Northfield, Ont.	494	1914	219	235
North Lake, Ont.	106–E	1916	162	185
North Portal, Sask.	†	1913	88	88
Northwood, Ont.	245	1913	57	81
Norton, N.B.	113–B	1913	44	73
Norton Mills, Vermont	23, 24, 25	1917	284	319
Notch Hill, B.C.	339–C	1918	31	45
Notre-Dame-du-Lac, Que.	64–B	1917	278	314
	O			
Oak Bay, N.B.	4–B	1917	275	313
Oakville, Ont.	193	1913	55	80
Oban, Sask.	14–H	1915	20	34
Okotoks, Alta.	60–D	1915	26	38
Orangeville, Ont.	267	1913	58	82
Osgoode, Ont.	117–A, 118–A	1913	52	78
Oshawa, Ont.	178–A, 179–A, 179	1913	54	79
Osler, Sask.	36–D	1914	228	240
Ottawa, Ont.	124–A, 125–A	1913	53	78
"	503, 504, 124–A	1914	220	235
Owen Sound, Ont.	286, 287, 288	1913	60	82
Oxbow, Sask.	55–C	1913	69	88
Oxford, Ont.	114	1917	286	320
Oxford, N.S.	136–B	1913	46	74
Oxford, Jct., N.S.	135–B	1913	45	74
" "	135–B	1916	146	173
	P			
Painsec, N.B.	MDXLIII	1916	‡	174
Pakenham, Ont.	68–G, 69–G	1917	250	293
Palgrave, Ont.	376	1913	64	86
Palmerston, Ont.	305	1913	61	83
"	305	1918	16	37
Paquette, Que.	557–B	1916	153	180
Paris, Ont.	222	1913	55	80
Parkbeg, Sask.	111–C	1914	229	241
Park Head Jct., Ont.	291	1913	60	83
Parkhill, Ont.	346	1914	221	236
Parry Sound, Ont.	419, 420	1914	223	237
Pasqua, Sask.	93–C	1913	71	89
Pelly, Y.T.	*118, 119*	1912	30	30
Pense, Sask.	99–C	1913	71	89
Perth, Ont.	112–G *to* 115–G	1917	253	295
Perth, N.B.	39–B	1917	277	314
Petitcodiac, N.B.	123–B	1913	45	73
Piapot, Sask.	141–C	1914	231	241
Pickering, Ont.	180–A–2	1913	54	79
Piedmont, N.S.	165–B	1913	47	74
Pierson, Man.	46–C	1913	68	88
Pike Creek, Ont.	253	1913	57	81
Pilot Mound, Man.	15–C	1913	67	87
Pincher, Alta.	94–D	1917	262	304
Pinewood, Ont.	20–E	1914	226	239

† International boundary monument.
‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Pinto, Sask.	67–C	1913	69	88
Plaster Rock, N.B.	301–B, 302–B	1914	213	232
Plessisville, Que.	665–B, 666–B	1918	12	34
Pomquet, N.S.	76–B	1913	48	74
Portal, North Dakota	†	1913	88	88
Port Arthur, Ont.	93–E *to* 95–E	1916	161	184
"	93–E	1918	21	40
Port Clyde, N.S.	442–B	1915	12	29
Port Colborne, Ont.	135–F *to* 137–F	1918	17	38
Port Dalhousie, Ont.	133–F, 134–F	1918	17	38
Porthill, Idaho	198–D	1917	268	307
Port Hope, Ont.	172, 172–A, 173.	1913	53	79
Port Robinson, Ont.	212	1913	63	85
Port Saxon, N.S.	441–B	1915	12	29
Port Union, Ont.	182	1913	54	79
Prescott, Ont.	118, 119	1917	286	320
Preston, Ont.	83–F, 84–F	1918	14	36
Prince Albert, Sask.	47–D, 48–D, 49–D	1914	228	240
Princeton, Ont.	224	1913	55	80
Princeville, Que.	668–B	1918	12	34
Pubnico, N.S.	454–B	1915	13	30
	Q			
Quarryville, N.B.	45–G	1916	152	178
	R			
Rainy River, Ont.	17–E	1914	226	239
Reford, Sask.	18–H	1915	20	34
Regina, Sask.	1–D, 2–D, 3–D	1913	71	90
Renfrew, Ont.	505, 506, 507	1915	17	32
"	505	1917	251, 254	294, 299
Resplendent, B.C.	117–H, 153–J	1918	29	44
Revelstoke, B.C.	311–C *to* 314–C	1917	271	310
Richford, Vt.	55	1917	282	318
Richmond, Que.	639–B, 640–B	1918	10	33
River Beaudette, Que.	DLXXVII	1917	‡	322
River Glade, N.B.	125–B	1913	45	73
Rivière-du-Loup, Que.	76–B, 77–B, 78–B	1917	279	315
Rivière Ouelle Jct., Que.	MCXXXVII	1917	‡	292
Roche-Percée, Sask.	65–C	1913	69	88
Rock Island, Que.	33–A	1913	49	75
Romford, Ont.	452	1914	224	238
Roosevelt, Minn.	13–E	1914	226	239
Rosedale, B.C.	36–J	1918	24	42
Rose Point, Ont.	565	1915	13	31
Rossport, Ont.	768	1918	20	40
Rosthern, Sask.	40–D	1914	228	240
Rothesay, N.B.	103–B, 104–B	1913	44	73
Rouleau, Sask.	88–C, 89–C	1913	70	89
Rouse Point, N.Y.	581–B	1918	8	32
Rush Lake, Sask.	120–C	1914	230	241
Russell, Ont.	499	1914	220	235
Ryley, Alta.	47–H, 48–H.....	1916	163	186
	S			
Sable River, N.S.	427–B	1915	11	29
Sackville, N.B.	MCCCCXXXVI, etc.	1916	‡	174
Salmon Arm, B.C.	335–C	1918	30	45
Sandstone, Alta.	58–D	1915	26	38
Sarnia, Ont.	357, 358, 359, 360	1914	221	236
Saskatoon, Sask.	29–D *to* 33–D	1914	227, 228	240
Sault Ste. Marie, Ont.	632, 633	1916	157	182
Sault Ste. Marie, Mich.	636	1916	157	182
Savona, B.C.	81–J	1918	26	43
Sawyerville, Que.	552–B	1916	153	180

‡Refer to Public Works Dept.
†International boundary monument.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Schreiber, Ont.	763, 764	1918	20	40
Scotia Jct., Ont.	553	1915	14	31
Scotstown, Que.	16–A–2	1913	49	76
Scott, Sask.	19–H	1915	20	34
Shag Harbour, N.S.	449–B	1915	12	29
Shallow Lake, Ont.	290	1913	60	83
Shannonville, Ont.	154	1917	288	321
Sharbot Lake, Ont.	124–G	1917	253	295
Shelburne, N.S.	433–B *to* 436–B	1915	11, 12	29
Shelburne, Ont.	271	1913	59	82
Sherbrooke, Que.	1, 2, 3	1917	283	319
" "	35, 36	1917	281	317
" "	3	1918	10	33
Sicamous, B.C.	330–C	1918	30	45
Siegas, N.B.	51–B	1917	277	314
Sirdar, B.C.	203–D	1917	268	308
Slate River, Ont.	87–E	1916	161	184
Smiths Falls, Ont.	88–G, 89–G, 107–G, 108–G	1917	251 to 253	295
South Durham, Que.	635–B	1918	10	33
South Maitland, N.S.	528–B, 529–B	1916	145	172
South Stukely, Que.	45	1917	281	317
Spence Bridge, B.C.	67–J, 68–J	1918	25	42
Spillimacheen, B.C.	159–D	1917	265	306
Sprague, Man.	10–E	1914	225	239
Springfield, N.S.	472–B	1916	147	175
Springhill, Que.	19–A–2, 20–A	1913	50	76
Springhill Jct., N.S.	CMX	1916	‡	173
Sprucedale, Ont.	556	1915	14	31
Sprucegrove, Alta.	64–H	1917	271	311
Stanbridge, Que.	67	1917	282	318
Stanley, Ont.	86–E	1916	161	184
Stanstead, Que.	34	1913	49	75
Steele, B.C.	138–D	1917	264	305
Steelton, Ont.	634, 635	1916	157	182
Stellarton, N.S.	MCCC	1913	‡	75
Stephen, Minnesota	1–C	1913	66	87
Stevens, Y.T.	*148*	1912	31	31
Stewart Crossing, Y.T.	*162, 163*	1912	32	32
Stickney, N.B.	32–B	1917	276	313
Stirling, Alta.	203–C, 204–C	1915	24	36
Stittville, Ont.	55–G	1917	249	293
Stoney Creek, Ont.	201	1913	63	85
Stoney Point, Ont.	250	1913	57	81
Stonyplain, Alta.	65–H	1917	271	311
Stottsville, Que.	79	1917	280	317
Stratford, Ont.	106–F *to* 108–F	1918	15	36
Sudbury, Ont.	454, 454–A	1914	225	238
"	567–A	1916	154	181
Sumas, Wash.	26–J, 27–J	1916	170	191
Sussex, N.B.	117–B	1913	44	73
Sutton, Que.	52	1917	282	318
Swalwell, Alta.	51–F	1916	164	187
Sweetgrass, Montana	216–C †	1915	25	37
Swift Current, Sask.	126–C, 127–C.	1914	230	241
	ST.			
St. Agapit, Que.	653–B *to* 655–B.	1918	11	34
St. Alexandre, Que. (Kamouraska Co.)	MCLI	1917	‡	292
Ste. Anne, Que. (Kamouraska Co.)	MXCIX	1917	‡	292
St. Anselme, Que.	214–B	1913	52	77
St. Armand, Que.	68, 69, 70	1917	282	318
St. Bazile, Que. (Chambly Co.)	604–B	1918	9	32
St. Bruno, Que. (Chambly Co.)	602–B	1918	9	32
St. Catharines, Ont.	207, 208	1913	63	85

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
St. Charles Jct., Que.	MCXXXI	1917	‡	291
St. Edouard, Que. (Napierville Co.)	589–B	1918	8	32
St. Evariste, Que.	195–B, 196–B	1913	51	77
St. George, N.B.	83–B	1917	279	316
Ste. Henedine, Que.	212–B	1913	52	77
St. Henri, Que. (Levis County)	216–B	1913	52	77
St. Hilaire, N.B.	262–B	1917	247	290
St. Hilaire, Que. (Rouville Co.)	607–B	1918	9	32
St. Honoré, Que.	70–B	1917	278	314
St. Hubert, Que.	600–B	1918	9	32
St. Hyacinthe, Que.	611–B *to* 613–B	1918	9	32
" "	615–B	1918	10	33
St. Jean Port Joli, Que.	MCVI	1917	‡	291
St. John, N.B.	97–B *to* 100–B	1917	280	316
St. Johns, Que.	75, 76	1917	280	317
St. Joseph-de-Lévis, Que.	220–B	1913	52	77
Ste. Julie, Que. (Megantic Co.)	662–B	1918	11	34
St. Lambert, Que.	597–B–2, 598–B	1918	9	32
St. Leonard, N.B.	50–B	1917	277	314
St. Liboire, Que.	626–B	1918	9	32
St. Louis, Que. (Beauharnois Co.)	88	1917	284	320
Ste. Madeleine, Que.	609–B	1918	9	32
Ste. Malachie, Que.	227–B	1917	244	289
St. Malo, Que. (Compton County)	555–B	1916	153	180
St. Margaret, N.S.	394–B	1915	9	28
St. Mary, Que. (Beauce County)	209–B	1913	51	77
St. Marys, Ont.	110–F, 111–F	1918	15	37
St. Pacôme, Que.	MXCVI	1917	‡	292
St. Paschal, Que.	MCXLVI	1917	‡	292
St. Philippe-de-Neri, Que.	27–G	1917	248	292
St. Pie, Que. (Bagot County)	618–B	1918	11	33
St. Pierre, Que. (Montmagny Co.)	565–B	1917	247	291
St. Polycarpe Jct., Que.	92	1917	285	320
Ste. Rosalie Jct., Que.	614–B	1918	9	32
Ste. Rose, Que (Temiscouata County)	62–B	1917	278	314
St. Stephen, N.B.	2–B, 3–B	1917	275	313
St. Vallier, Que.	MCXXV	1917	‡	291
	T			
Taber, Alta.	186–C, 187–C	1915	23	36
Taft, B.C.	323–C	1918	30	44
Takhini, Y.T.	*20, 21*	1912	25	25
Tako, Sask.	20–H	1915	20	34
Tara, Ont.	293	1913	60	83
Tatamagouche, N.S.	147–B	1913	46	74
Thamesville, Ont.	243–A	1913	57	81
Thedford, Ont.	349	1914	221	236
Thornhill, Man.	9–C	1913	66	87
Thorold, Ont.	210, 211	1913	63	85
Three Hills, Alta.	53–F	1916	164	187
Tichborne, Ont.	146–G	1917	255	300
Tofield, Alta.	50–H, 51–H	1916	163	186
Tompkins, Sask.	138–C	1914	231	241
Toronto, Ont.	185 *to* 189	1913	54	79
Tottenham, Ont.	377–A	1913	64	86
Trenton, Ont.	161	1917	288	322
Tring Jct., Que.	204–B	1913	51	77
Trochu, Alta.	55–F	1916	164	187
Truro, N.S.	534–B *to* 537–B	1916	146	172
Tupperville, Ont.	369	1914	222	236
Tusket, N.S.	460–B	1915	13	30
Tweed, Ont.	174–G *to* 176–G	1917	256	296

‡Refer to Public Works Dept.

†Also bench-mark in international boundary monument.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
	U			
			Page	Page
Unity, Sask.	22–H	1915	20	34
Upper Woods Harbour, N.S.	451–B	1915	12	29
Upton, Que.	627–B, 628–B	1918	9	32
Utopia, Ont.	387	1913	65	86
	V			
Valleyfield, Que.	89	1917	284	320
Valley Jct., Que.	207–B	1913	51	77
Van Buren, Maine	50–B	1917	277	314
Vanceboro, Maine	12–B, 13–B	1917	275	313
Vancouver, B.C.	1–J *to* 5–J	1916	168	190
Vera, Sask.	23–H	1915	20	34
Verona, Ont.	152–G	1917	255	300
Versailles, Que.	72	1917	280	317
Victoriaville, Que.	670–B *to* 672–B	1918	12	34
Viking, Alta.	43–H	1916	162	185
Vulcan, Alta.	68–D, 69–D	1915	26	38
	W			
Wabamun, Alta.	69–H	1917	272	311
Wainwright, Alta.	36–H	1915	21	34
Wakefield, Que.	469, 470	1914	218	234
Walkerville, Ont.	255	1913	57	81
Wallaceburg, Ont.	367	1914	222	236
Walsh, Alta.	155–C	1915	22	35
Warman, Sask.	35–D	1914	228	240
Warner, Alta.	209–C, 210–C	1915	24	36, 37
Warroad, Minn.	12–E	1914	226	239
Warwick, Que.	674–B, 675–B	1918	12	34
Waterloo, Ont.	98–F, 99–F	1918	15	36
Waterville, N.S.	489–B	1916	148	175
Waterville, Que.	9	1917	283	319
Watt, N.B.	8–B	1917	275	313
Webb, Sask.	132–C	1914	230	241
Webbwood, Ont.	585	1916	155	181
Welland, Ont.	213	1913	64	85
Welland Jct. Ont.	214	1913	64	85
Westchester, N.S.	CMLX	1916	‡	172
Westfort, Ont.	89–E	1916	161	184
West Huntingdon, Ont.	181–G	1917	257	301
West Merigomish, N.S.	163–B	1913	47	74
Westmount, Que.	810	1918	13	35
Weston, Ont.	256–A	1913	58	82
Weyburn, Sask.	80–C, 81–C	1913	70	89
Whitby, Ont.	180–A	1913	54	79
Whitefish Lake, Que.	487	1914	219	234
Whitehorse, Y.T.	*1*	1912	25	25
Whitemouth, Man.	14–F	1915	18	33
White Pass, B.C.	*42–R, 43–R*	1912	23	23
White River, Ont.	723, 723–A	1918	18	39
Whiterock, B.C.	17–J, 18–J	1916	169	190
Whitewater, Man.	35–C	1913	68	88
Whitney, Ont.	536	1915	15	31
Wilcox, Sask.	86–C, 87–C	1913	70	89
Wilmot, N.S.	485–B	1916	148	175
Winchester, Ont.	109	1917	285	320
Windsor, Ont.	255	1913	57	81
Windsor, N.S.	502–B *to* 505–B	1916	149	176
Windsor Jct., N.S.	MXXXIV	1916	‡	171
Windsor Mills, Que.	644–B, 645–B	1918	10	33
Wingham, Ont.	314	1913	61	83
Winnifred, Alta.	176–C	1915	23	35

‡Refer to Public Works Dept.

APHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Concluded.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Winnipeg, Man.	1–F, 2–F, 3–F	1915	17	33
Winona, Ont.	202	1913	63	85
Winter, Sask.	25–H	1915	20	34
Wolfville, N.S.	495–B *to* 497–B	1916	148, 149	175
Woodstock, Ont.	226, 227	1913	55	80
Woodstock, N.B.	25–B, 26–B, 27–B	1917	276	313
Worthington, Ont.	577	1916	154	181
Wounded Moose, Y.T.	*179*	1912	33	33
	Y			
Yahk, B.C.	187–D	1917	267	307
Yarmouth, N.S.	463–B, 464–B, 465–B	1915	13	30
Yellow Grass, Sask.	83–C	1913	70	89
Yukon Crossing, Y.T.	*94*	1912	29	29
	Z			
Zumbro, Sask.	27–H	1915	20	34

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Natural Scale, 1/31,680,000
Scale 400 miles to one inch
Precise Levelling, Published.
Precise Levelling, Not Published.
Victoria Island
Wollaston Land
Southampton I.
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HUDSON STRAIT
NORTH WEST TERRITORIES
YUKON
ALASKA
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
GULF OF ST. LAWRENCE
PACIFIC OCEAN
ATLANTIC OCEAN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE ERIE
LAKE ONTARIO
Dawson
White Pass
Prince Albert
Saskatoon
Edmonton
Calgary
Banff
Field
Golden
Revelstoke
Kamloops
Vancouver
Victoria
Nelson
Rossland
Grand Forks
Midway
Coutts
Lethbridge
Medicine Hat
Swift Current
Moose Jaw
Regina
Portal
North Portal
Estevan
Brandon
Virden
Winnipeg
Kenora
Fort Frances
Port Arthur
Sault Ste. Marie
Michipicoten
Chapleau
Cochrane
Stephen
Jasper
Loos
Glenogle
Mitchell
Olivine
Shanley
North Lake
Hornepayne
Longlac
Nakina
Depot Harbour
Parry Sound
Toronto
Hamilton
Niagara Falls
Port Colborne
Fort Erie
Windsor
Chatham
Sarnia
Owen Sound
Orillia
Lindsay
Peterborough
Belleville
Kingston
Brockville
Cornwall
Ottawa
Pembroke
Renfrew
Arnprior
Carleton Place
Smiths Falls
Perth
Almonte
Lanark
Brockville
Prescott
Alexandria
Hawkesbury
Lachute
St. Jerome
St. Philippe de Neri
St. Adelaine
Joliette
Berthierville
Three Rivers
Shawinigan Falls
Grand Mere
Roberval
Lake St. John
Chicoutimi
Jonquiere
Arvida
Kenogami
Riviere du Loup
Edmundston
Woodstock
Grand Falls
Campbellton
Bathurst
Dalhousie
Newcastle
Chatham
Fredericton
St. John
Moncton
Sackville
Amherst
Shediac
Sussex
Truro
Halifax
Windsor
Kentville
Yarmouth
Digby
Annapolis
Bridgewater
Liverpool
Lunenburg
New Glasgow
Pictou
Antigonish
Sydney
Glace Bay
Louisburg
Port aux Basques
Corner Brook
Grand Falls
Bay of Islands
Gander
Bonavista
Twillingate
Fogo
Carbonear
Harbour Grace
Placentia
St. John's
Trepassey
Argentia
Burin
Fortune
Grand Bank
Channel
Port aux Basques

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HON. ARTHUR MEIGHEN, *Minister;* W. W. CORY, *Deputy Minister*

GEODETIC SURVEY OF CANADA
NOEL OGILVIE, *Superintendent*

UNIVERSITY OF ILLINOIS
JUL 28 19

GEODETIC TRIANGULATION

ADJUSTMENT

OF

GEODETIC TRIANGULATION

IN THE PROVINCES OF

ONTARIO and QUEBEC

PUBLICATION No. 2



OTTAWA
THOMAS MULVEY
PRINTER TO HIS MOST EXCELLENT MAJESTY
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CONTENTS

I PAGE

Introduction 5

II

The Dusable—Haldimand Net—
Description of Net 11
Object of Present Adjustment 11
Co-ordinate Adjustment 11
Cursory Explanation and Development of Formulae 12
The Observation Equations, how formed 12
The Conditional Equations and their absorption by the Normal Equations 13
The Orientation Factor Z, how treated 14
The Normal Equations, Partial and Collective 16
Nature of Successive Differential Solutions and Comparison of Values 16
Conclusions on Twist of the Net 17
Accuracy of the Adjustment 18
The Precisions 19
The Observation Equations tabulated 21
Corrections due to Inclusion of Two Bases and Two Laplace Points 25
Tabulation of Final Values.
Adjusted Directions 26
Adjusted Angles of Triangles 32
Dusable—Haldimand Net 45

III

The Ottawa—Groveton Net—
Introduction 46
Reduction to Centre of Station 46
Reduction to Sea Level 47
Preliminary Co-ordinates 48
Differential Formulae 49
Evaluation of Coefficients 49
Table of Coefficients 49
Calculation of Absolute Terms 50
Observation Equations 50
Elimination of Z 51
Normal Equations 56
Precision Formulæ 59
Evaluation of Final Values 60
Accuracy of the Adjustment 63
Concluding Remarks 67
Ottawa Groveton Net 69

IV

The Scotch Bonnet Net—
Introduction 70
Nature of Adjustment 70
The Conditions 70
Condition Equations 70
Accuracy of the Adjustment 71
Absolute Terms 71
Precisions 72
Tabulated Final Results 72
Scotch Bonnet Net 73

V

The Coteau Base Net—
Introduction 74
Preliminary Corrections to Observed Directions 74
Spherical Excesses 74
Condition Equations 75
Correlate Equations and Equations for the Probable Error of Sides 78
Formation of Equations for Weights of Exterior Sides 80

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PAGE
Normal Equations and Solution ... 81
Backward Solution ... 103
Evaluation of Corrections to Directions ... 104
O—C Test ... 105
Corrections and Adjusted Directions ... 106
Distances ... 107
Probable Errors of Exterior Sides ... 108
Accuracy of the Triangulation ... 108
Geographical Co-ordinates ... 109
Coteau Base Net ... 110

VI

The Rigaud—Standon Net—
Introduction ... 111
Interesting Features ... 111
Corrections to Observed Directions ... 115
Condition Equations ... 115
Correlate Equations and Equations for Exterior Sides ... 116
Normal Equations and Corrections to Directions ... 116
Probable Error of a Direction ... 117
O—C Test ... 117
Distances ... 118
Probable Errors of Exterior Sides ... 119
Accuracy as Shown by the Angle and Side Equations ... 119
Accuracy of the Triangulation ... 120

VII

Rigaud—North Mountain Net—
Introduction ... 121
Weights ... 121
Preliminary Corrections to Observed Directions ... 121
Selection of Angle and Side Equations ... 121
Condition Equations ... 122
Equations for Weights of Exterior Sides ... 123
Correlate Equations ... 126
Normal Equations ... 128
Reduced Normal Equations ... 130
Evaluation of Correlates ... 132
Evaluation of *v*'s ... 134
O—C Test ... 138
Tabulation of Directions ... 139
Tabulation of Triangles ... 140
Comparison of Log. Distances ... 143
Rigaud—North Mountain Net ... 145

VIII

The King Mountain—Murray Net—
Introduction ... 146
Preliminary Corrections to Observed Directions ... 146
Condition Equations ... 146
Correlate Equations ... 152
Backward Solution ... 157
Computation of *v*'s ... 158
Adjusted Directions ... 158
Tabulation of Triangles ... 159
O—C Test ... 162
Evaluation of Lengths ... 162
Geographical Co-ordinates ... 162
Accuracy of the Adjustment ... 163
Accuracy of the Field Work ... 163
King Mountain–Murray Net ... 164

IX

Geographical Positions ... 165
Descriptions ... 172
Index ... 189

I

INTRODUCTION

This Report consists of the following:

Values of latitudes and longitudes of points, lengths and azimuths of lines for the use of engineers in engineering problems and mapping and in surveys of all kinds.

Descriptions of location of such points in the field, showing the connection of the geodetic point to other survey marks.

Section I, page 5. Introduction by W. M. Tobey.
Section II, page 11. On Final Values by W. M. Tobey.
Section III, page 46. On Final Values by J. E. Ratz and D. J. Fraser.
Section IV, page 70. On Final Values by D. J. Fraser.
Section V, page 74. Illustration of Methods by J. L. Rannie.
Section VI, page 111. Illustration of Methods by J. L. Rannie.
Section VII, page 121. Illustration of Methods by D. J. Fraser.
Section VIII, page 146. Illustration of Methods by H. B. Kihl.
Section IX, page 165 Geographic positions and descriptions of stations established.

(a) Values

The values are in all cases final, and are given on page 165, which is part of the report by J. E. Ratz on the adjustment of the Dusable–Haldimand net. Values other than the final ones have been obtained in previous years, but are not here published. These preliminary values arose to meet the demands of the public, before the controls, bases and Laplace points, had been inserted.

In obtaining these final values as given on page 165, one net in its entirety was adjusted, depending upon the North American Datum line Bellevue to Royal and controlled by two bases, one near Coteau and one near Belleville, and by two Laplace points, one at the station Murray and one at the station Ottawa. This net thus includes two or three smaller nets which were solved before our controls were established. As these nets are smaller, and therefore more easily followed by those desirous of studying the subject of adjustments, it was thought well to publish their separate adjustments in detail only so far as METHODS are concerned, and not as regards actual values obtained, as such values would be superseded by those given on pages 165 to 171.

(b) Descriptions

These descriptions which are found on pages 172 to 187 and whose objects are explained on this page are to enable surveyors to discover the location of the geodetic points of this survey by ascertaining the relation of such points to other surveys.

Purpose and Object of Data

While the accumulated data of a Geodetic Survey will be more and more welded together by adjustments to give scientific information as to the size, shape, etc., of the earth, yet it is felt that the main purpose of the Geodetic Survey of Canada, for the present, is to HELP other surveys, engineers and departments doing survey work by giving them a CONTROL for their work, thus permitting them to feel that the unavoidable accumulated errors of their surveys are better controlled and regulated, and the accuracy of such surveys thereby increased.

Along this line, information has been given out at various times to the following:—

Militia Department, to control accuracy of their military maps, especially those of the province of Quebec.

Naval Department, Hydrographic Survey, to control the survey of the St. Lawrence river and the triangulation of the north shore of lake Ontario.

Interior Department, Geographer's Branch, as control of compiled maps.

Mines Department, Geological Survey, as aid for making their maps.

Province of Quebec, for establishing an irrigation survey in region of river St. Francis.

It may be added, that requests for information in regions not yet reached by the Geodetic Survey of Canada and which we are consequently unable to give, have been made by the Public Works Department; province of Quebec, along river St. Maurice; the city of Toronto and others.

Methods used to test Field Work

As the work from the field enters the office, the following tests are to be applied:—

i. To see if the angle equations are properly satisfied. The average error is 1·5″ when the angle equation is of the triangle sort.

ii. To see if the side equations are also properly satisfied (*see* p. 146 for fuller description of side equations). Here the test is that the "absolute average v" shall not exceed 0·4″ for primary work. This "absolute average v" is found by simply adding the terms of the side equations together irrespective of sign and dividing the result into the numerical term.

Generally speaking we may expect errors as given by the adjustment of not greater than three times this "average v".

Methods used in the Office to Refine Field Work

At the outset, it might be well to remark that this sub-article on " Methods Used in the Office to Refine Field Work " is only meant to be an outline of what has to be done in the office, so that those new members who may join the office in the future, and others as well, may be able to know the methods that were employed in the past adjustments. Methods therefore are only indicated and reference will be given to the sections of the different books wherein such methods are contained and where they are most fully described. While Helmert's Higher Geodesy in connection with Wright and Hayford's Adjustment of Observations was mainly used and consulted, very much assistance was derived from the United States Coast and Geodetic Survey Reports on Geodesy, and it is felt that very much assistance will always be derived from that admirable publication " Application of the Theory of Least Squares to the Adjustment of Triangulation " by Oscar S. Adams of the United States Coast and Geodetic Survey, a book which has only recently been published.

If the field work has survived the preliminary tests as given above, the next step is to correct the observations for the small systematic errors due (i) to elevation of object pointed upon, and (ii) to the fact that the true line between two stations should be a geodetic line and not a normal plane section.

(i) *Correction due to Elevation of Object sighted upon*

This is primarily due to the fact that the normals to an ellipse and consequently to an ellipsoid of revolution do not all pass through the same point as is the case in a circle or sphere. The consequence is that a revolving plane through one normal would not pass through all points in another normal at the same time, but would intersect the second normal at different points depending upon the amount of rotation, thus:—

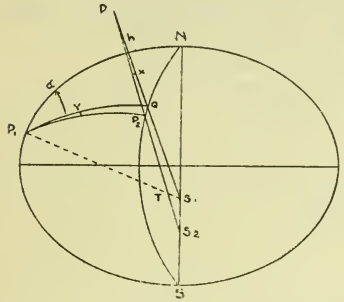


Fig. 1

$P_1 S_1$ is normal at P_1.

$P_2 S_2$ is normal at P_2 not intersecting the line SN and not parallel to $P_1 S_1$.

Evidently a plane through $P_1 S_1$ and P_2 of azmuth α would have to be further revolved by an angle y to cut the line at P (a flag signal for example which is h high).

Before this extra angle y is determined, we will first evaluate x of figure 1.

As h is small compared with the earth's radius, x can be assumed the same in figure 2 where P_3 is a point havin the same ϕ as P_2.

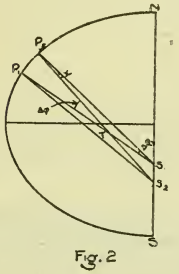


Fig. 2

Approximately arc $P_1 P_3 = P_1 S_1 \Delta\phi_1 = N \Delta\phi_1$.
Approximately arc $P_1 P_3 = P_1 T \Delta\phi = R_1 \Delta\phi$.

$$\text{therefore } x = (\Delta\phi - \Delta\phi_1) = \Delta\phi \left(1 - \frac{\Delta\phi_1}{\Delta\phi}\right) = \Delta\phi \left(1 - \frac{R_1}{N_1}\right)$$

$$= \Delta\phi \frac{\delta \cos^2 \phi_1}{(1 + \delta \cos^2 \phi_1)} \text{ since } \frac{N_1}{R_1} = 1 + \delta \cos^2 \phi_1$$

$$\text{where } \delta = \frac{e^2}{1 - e^2}.$$

Returning now to our case to find the value of y

$$y = \frac{P_2 Q \sin \alpha}{P_1 P_2} = \frac{P_2 Q \sin \alpha}{S} = \frac{h x \sin \alpha}{S}$$

$$= \frac{h \sin \alpha}{S} \Delta\phi \frac{\delta \cos^2 \phi_1}{(1 + \delta \cos^2 \phi_1)}$$

$$= \frac{\delta h \sin \alpha \cos \alpha \cos^2 \phi_1}{(1 + \delta \cos^2 \phi_1) N}, \text{since } \Delta\phi = \frac{S \cos \alpha}{N} + \text{"2"}$$

$$= \frac{\delta h \cos^2 \phi_1 \sin 2\alpha}{2N} \text{ ultimately}$$

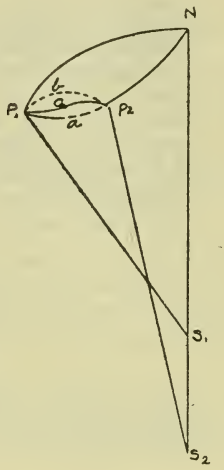
$$= 0.108'' \, h \cos^2 \phi_1 \sin 2\alpha \text{ approximately where } h \text{ is in kilometers.}$$

See, for fuller information on this correction, Helmert's Geodesy, p. 189, Crandall p. 169, Jordan III, p. 390.

Thus it will be seen that this systematic correction which theoretically should be applied to every observed direction is very small and in fact generally much smaller than the probable error of a direction which is 0.4″ approximately (see p. 19) and therefore the correction can be generally omitted.

In the province of Quebec and other places this correction was studiously applied, but in future there will be little occasion for its use considering the low rolling character of our country.

(ii) *Correction due to fact that a geodetic line should be used in place of a line made by a normal plane section*



Here P_1 a is the line made by the intersection of the plane P_1 S_1 P_2 with the ellipsoid and P_2 b is the line made by the intersection of the plane P_2 S_2 P_1 with the ellipsoid and these two lines do not coincide because of the fact that the normals at P_1 and P_2 do not intersect at a common point as is the case with a sphere, but at the two distinct points P_1 and P_2.

The real line to be used in geodetic work is the line P_1 c P_2 which is called a geodetic line and which has the property of being the shortest line between P_1 and P_2 and whose inclination to the line P_1 a and P_2 b is very small being given by the expression

$$-0.028'' \cos^2 \phi \sin 2a \left(\frac{c}{100}\right)^2$$

where a is the azimuth of the line
and c is the distance in kilometers.

Thus all observed directions which are along the line P_1 a or P_2 b should be corrected by the above correction. This correction being much smaller than 0.4″, the probable error of a direction, is not generally applied.

(iii) *Selection of Angle and Side Equations*

The number of angle equations necessary to incorporate a new point being $n-1$ where n is the number of lines doubly observed, leading to such point, and the number of side equations necessary being $n-2$ where the lines are not doubly observed, it follows that generally there is a *choice* in the selection of such equations every time a new point is incorporated into the old structure.

Thus in a quadrilateral if two new points 3 and 4 are added to the old points 1 and 2, three angle equations and one side equation come into play and there is a choice in the selection of such.

For the first few years of the office work the following was the method of choice, the angle equations being:—

$$(3) - (1) + (12) - (10) + (9) - (7) + (6) - (4) + E_{1234} = C_1$$

$$(8) - (7) + (6) - (5) - (12) + (11) - (2) + (1) + E_{x24} - E_{x13} = C_2$$

$$(11) - (10) + (9) - (8) + (4) - (5) + (2) - (3) + E_{x34} - E_{x12} = C_3$$

while the side equation was taken with X as pole, thus,—

$$\frac{\sin(12-11)\sin(3-2)\sin(6-5)\sin(9-8)}{\sin(11-10)\sin(2-1)\sin(5-4)\sin(8-7)} = 1$$

which was reduced to linear form as given in Wright and Hayford, p. 197, where C_1, C_2, and C_3 are constants depending upon the observations, where E is the Spherical Excess of the figure given by the subscript.

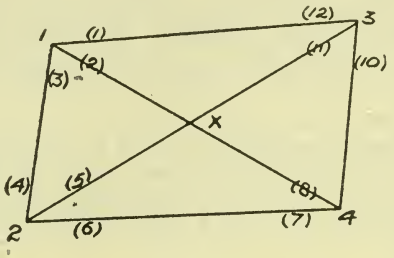


FIG. 4.

This method undoubtedly will give the sharpest solution (see Johnson's Theory and Practice of Surveying, p. 515, and Jordan I, p. 249) for theory on angle equations and Jordan I, p. 233 to p. 246 for theory of selection of side equations.

This method of selection has now been superseded by that of picking out any three triangle equations in the quadrilateral and choosing the pole at 1, 2, 3 or 4 in place of X, thus giving rise to a 6-term side equation.

Thus considerable labour is saved and any loss of accuracy is easily shown to be well within the probable error of a direction which is generally $0{\cdot}4''$.

(iv) *Probable Errors of Side, Azimuth, Latitudes and Longitudes of Points*

In all the adjustments the probable errors of the lengths of the external sides of the nets were determined. Thus is one able to form some idea of where strength or weakness exists in the old triangulation scheme, and so guide himself accordingly in the planning out of new field work. This applies particularly to the reconnaissance man who can thus determine R (the strength of a side as given through a chain of triangles) starting from one side of an adjusted triangulation.

The probable error of a side . . . etc., does not depend, however, just on the observations which constitute a chain; obviously all the observations of the net must affect such probable error.

If the adjustment is done by the method of condition, we express a differential of the side, or of an azimuth, latitude or longitude as a function of the adjusted values, and place such function at the right hand side of the correlate equations. See page 78 for an example. The theory of such is given in Wright and Hayford's, page 163 or Helmert's, Adjustments, page 288.

If the adjustment is, however, done by the method of co-ordinates, one function expressed as a function of the adjusted values is placed at the right hand side of the normal equations. See page 57 of the Ottawa-Groveton net for example. The theory of such is given in Wright and Hayford's, page 138 or Helmert's Adjustments, page 182.

The probable errors of the latitudes and longitudes of distant adjusted points are determined generally by the co-ordinate adjustment. A tabulation of some such values is given on page 20, and is interesting as being able to give at once the probable error of the position of a point, as is the case with ordinary astronomical observations for latitude and longitude.

The order in which the normal equations were solved might be dwelt upon briefly. Three methods have been employed.

First, the equations were so arranged as to present a diagonal in which the numbers decrease from left to right. This undoubtedly gives the sharpest solution (*see* Jordan I, p. 248) but as it involves far more labour and very little accuracy of solution, in fact an increase of accuracy which is within the probable error of the adjustments, this method has been abandoned.

Second, the equations were so arranged as to have the diagonal of the normal equations present a series of numbers increasing from left to right. This is effected generally by placing the angle equations first in the correlate equations and the side equations to the right of them. The Doolittle method of evaluation as given in Wright and Hayford's Adjustments, page 119, was used with very satisfactory results.

Third, the conditions were so arranged as to include those involving each new point, i.e., the correlate equations would be composed of a series of angle and side equations of one point, followed by a series of angle and side equations necessary to the inclusion of a second point, and so on for the inclusion of each new point. This seemed to give very good results, the Doolittle method of evaluation being used.

II

DUSABLE-HALDIMAND NET

Description of Net

This net, starting from a region of Ontario about 30 miles west of Belleville and running along the shore of lake Ontario, thence following the St. Lawrence river through the province of Ontario, on arriving in the province of Quebec spreads out so as to include a part of that province to the south of the St. Lawrence river, and finally terminates about 40 miles east of the city of Montreal.

Previously the territory covered by the net had been broken up into several nets and each given a separate adjustment to give temporary values according as the survey progressed with time.

Thus, in order of time, were adjusted by the method of conditions the following nets:—

Coteau base net..... page 74
Rigaud—North Mountain net..... page 121
Royal—North Mountain net
King Mountain—Murray net..... page 146
Royal—Standon net..... page 111

Object of Present Adjustment

With the establishment of two Laplace points, one at Ottawa and one at Murray, and the measurement of another base near Belleville, the westerly limit of the net, a new adjustment was necessary, embracing *as a whole* all the previous nets.

With this in view, and in conformity with the agreement in 1913 between the late Dr. King, Superintendent of the Geodetic Survey of Canada, and Mr. O. H. Tittmann, Superintendent of the United States Coast and Geodetic Survey, whereby our triangulation and its results were to be placed on a common datum to be known as the North American Datum, the adjustment was made to include the United States Coast and Geodetic Survey primary line Royal–Bellevue, while at the same time the two bases and two Laplace points were incorporated.

The absolute values of the discrepancies that had to be taken up and distributed throughout the net, were as follows:—

4″·705 to the Geodetic Azimuth, Murray—Grimsthorpe and longitude of Murray.
5″·377 to the Geodetic Azimuth, Murray—Asphodel " " "
3″·032 to the Geodetic Azimuth, Ottawa—King Mountain and longitude of Ottawa.
4″·243 to the Geodetic Azimuth, Ottawa—Wakefield " " "

These absolute values were obtained from the ordinary Laplacian equation $a_o - a_g = -(\lambda_o - \lambda_g) \sin \varphi$.

For the enlargement of this condition to fit into a co-ordinate adjustment see page 13.

For formulæ for the base condition see page 13.

The Co-ordinate Adjustment used

As the previous net adjustments by the method of conditions had given values of the ϕ and λ of points which were very near the truth and would be considered as very approximate, a co-ordinate method of adjustment was used to maintain the fixed positions of the United States Coast and Geodetic Survey

points Royal and Bellevue, and it was felt that such an adjustment would lend itself easily to the establishment of the condition equations in our case to maintain the length of the two included bases, and to express the fact that two Laplacian equations were formed thus re-defining the azimuth at the stations where such Laplacian work was done.

Though very satisfactory results were obtained by this method of adjustment and though it lends itself with the greatest ease to the incorporation of any conditions, (*see* p. 14 for brief theory, and p. 60 for a concrete case as applied to our net Dusable–Haldimand,) yet the use of such an adjustment generally is not recommended on account of the extra labour involved in its solution over that of a conditional adjustment. The conditional adjustment, while in many cases being difficult as to the method of forming certain desired conditions, is on the whole more easily handled and will in the future be the main adjustment used in the Geodetic Survey of Canada, relegating to secondary or other similarly highly conditional work the co-ordinate method of adjusting.

Cursory Explanations on Development of Formulæ

1. *The Observational Equations, how formed.*

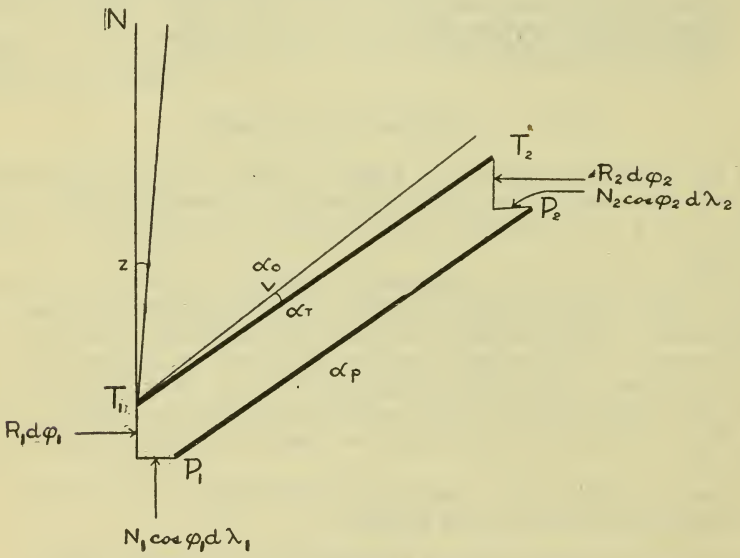


Fig. 5.

Let P_1 and P_2 be preliminary positions of two points 1 and 2
Let T_1 and T_2 be true adjusted positions of such two points
Let a_P be the inverse azimuth corresponding to two preliminary positions P_1 and P_2
Let a_T be true inverse azimuth corresponding to the points T_1 and T_2
Evidently da, i.e. $a_T - a_P$, must be some function of $d\phi_1$, $d\lambda_1$, $d\phi_2$ and $d\lambda_2$
In other words $da = f_1 d\phi_1 + f_2 d\lambda_1 + f_3 d\phi_2 + f_4 d\lambda_2$ where the f's stand for terms which must be some functions of the position data of the line.

With this understanding, we have

$$a_T = a_P + da$$

But $a_T = a_o + v + z$

where "z" is an orientation factor and is more fully explained on page 14.

Hence our observational equation is

$$v_{12} = -z + \alpha_p - \alpha_o + da$$

$$= -z + \alpha_p - \alpha_o + \frac{R_1 \sin \alpha_{12}}{m} d\phi_1 + \frac{R_2 \sin \alpha_{21}}{m} d\phi_2 + \frac{N_2 \cos \phi_2 \cos \alpha_2}{m} (d\lambda_2 - d\lambda_1)$$

$$= -z + \alpha_p - \alpha_o + A_1 d\phi_1 + A_2 d\phi_2 + B_2 (d\lambda_2 - d\lambda_1).$$

where $\frac{m}{s} = 1 - \frac{s^2}{6a_o^2} +$

$= 1 +$ "2"

where S = length of a side

where R = radius of curvature for a meridional section

where N = radius of curvature for a normal section

where α_{12} denotes that the observation took place at station 1, with pointing on station 2.

For information *re* the derivation of the co-efficients of $d\phi_1$, $d\phi_2$, $d\lambda_1$, $d\lambda_2$ in the observation equation see United States Coast and Geodetic Survey Special Publication No. 28 on "Application of the Theory of Least Squares to the Adjustment of Triangulation" or Helmert's Hohere Geodasie, page 282.

The observation equations at the different points are tabulated on pages 21 to 25.

2. *The Conditional Equations, how formed.*

One of the main reasons for the use of the co-ordinate adjustment was the great ease of formation of the condition equations especially if such conditions were difficult to locate and form as is often the case with a conditional adjustment.

Thus to form a length equation

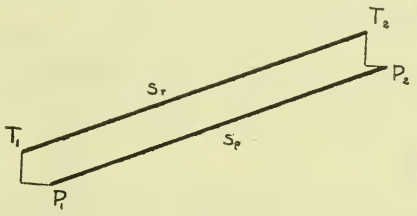


Fig. 6.

where P_1, P_2, T_1 and T_2 have the same significance as on page 12 and Sp denotes a length corresponding to the assumed position P_1 and P_2

where S_T denotes a measured length corresponding to adjusted positions T_1 and T_2 we see that ds i.e. "$S_T - S_p$" must be some function of $d\phi_1$, $d\lambda_1$, $d\phi_2$ and $d\lambda_2$

Hence our condition is

$$-(S_T - Sp)\frac{1}{\sin 1''} = R_1 \cos \alpha_{12}\, d\phi + R_2 \cos \alpha_{21}\, d\phi_2 + N_2 \cos \phi_2 \sin \alpha_2\, (\Delta\lambda_1 - \Delta\lambda_2)$$

Again to transform a Laplacian equation so as to be suitable material to be incorporated into a co-ordinate adjustment, we have,—

$\alpha_o - \alpha_g = -(\lambda_o - \lambda_g) \sin \phi$ the ordinary Laplacian equation, for whose derivation see United States Coast and Geodetic Survey Report entitled "Supplementary Investigation in 1909" or Jordan Vermessungshunde III, page 610, or Helmert's Hohere Geodasie, page 537.

or $(\alpha_o - \alpha_p - d\alpha) = -(\lambda_o - \lambda_p - d\lambda) \sin \phi$

or $\alpha_o - \alpha_p = -(\lambda_o - \lambda_p) \sin \phi + A_1 d\phi_1 + A_2 d\phi_2 - (B_2 - \sin \phi_1)\, d\lambda_1 + B_2\, d\lambda_2$

Where A_1, A_2 and B_2 have the designation as given above.

3. *The Conditional Equations and their Absorption by the Normal Equations*

If a number of conditions, in our case 4 Laplace and 2 base conditions, occur in conjunction with the adjustment of co-ordinates, we could either eliminate these conditions before the normal equations were formed, or employ the use of correlates, equal in number to that of conditions, and apply such correlate

equations directly to the body of the normal equations as shown by the following scheme:—

$\Delta\phi_1$	$\Delta\lambda_1$	$\Delta\phi_2$	$\Delta\lambda_2$	Absolute term	K_1	K_2	K_3	K_4	K_5	K_6
(aa)	(ab)	(ac)		(al)	p_1	p_2	p_3	p_4	p_5	p_6
	(bb)	(bc)		(bl)	q_1	q_2	q_3	q_4	q_5	q_6
		(cc)		(cl)	r_1	r_2	r_3	r_4	r_5	r_6

where $p_1, q_1 r_1$ . . . , etc., are the coefficients of the Laplace and base conditions.

The theory for thus allocating the conditions to the end of the normal equations might not be out of place.

Let the observation equations in $\Delta\phi_1$, $\Delta\lambda_1$ . . . be as follows:—

$\Delta\phi_1$	$\Delta\lambda_1$	$\Delta\phi_2$	$\Delta\lambda_2$	abs. term	Residual
a_1	b_1	c_1	d_1	$+l_1$	v_1
a_2	b_2	c_2	d_2	$+l_2$	v_2
a_3	b_3	c_3	d_3	$+l_3$	v_3
a_4	b_4	c_4	d_4	$+l_4$	v_4

etc.,

and let the condition equations be:—

$\Delta\phi_1$	$\Delta\lambda_1$	$\Delta\phi_2$	$\Delta\lambda_2$	abs. term
p_1	p_2	p_3	p_4	$-p_o$
q_1	q_2	q_3	q_4	$-q_o$
r_1	r_2	r_3	r_4	$-r_o$
etc.				

Using correlates K_1, K_2, K_3 . . . etc., equal in number to the number of conditions, the minimum function to be *differentiated* will take the form:—

$$(vv) + 2K_1 (p_o + p_1 \Delta\phi_1 + p_2\Delta\lambda_1 + p_3\Delta\phi_2 + p_4\Delta\lambda_2 \ . \ . \ .) + 2K_2 (\ . \ . \ . \ ) + \text{etc.}$$

Differentiating this with respect to $\Delta\varphi_1$, $\Delta\lambda_1$, etc., we obtain

$$(av) + K_1p_1 + K_2q_1 + K_3r_1 + \ldots\ldots\ldots\ldots = 0$$
$$(bv) + K_1p_2 + K_2q_2 + K_3r_2 + \ldots\ldots\ldots\ldots = 0$$
$$(cv) + K_1p_3 + K_2q_3 + K_3r_3 + \ldots\ldots\ldots\ldots = 0$$
etc.

or unravelling, by substituting for the v's and remembering that we have as many conditions to add as horizontal rows, as we have K's, we obtain normal equations in $\Delta\phi_1$, $\Delta\lambda_1$, . . . K_1, K_2, K_3 . . . etc., symmetrical about a diagonal.

4. *The Orientation Factor " z ", how treated.*

The necessity of the consideration of an orientation factor " z " in the observation equations of p. arises from the fact that, in the field, an observer does *not* observe azimuths directly referred to a line where azimuth is zero, but that he observes directions referred to an initial line considered as having a deduced reading of $0° + v$, where " v " is a correction to the observation due to pointing, etc.

If the angle between the meridian and this initially observed direction is known, the azimuth of such initial line can be written out, and similarly the

azimuths of all the other directions can be written by simply adding this angle value to all the directions. As this angle value is not generally known exactly but has an outstanding error " z ", it follows that in the reduction of the system of directions to that of a system of azimuth readings, all such readings will have included in them an unknown correction " z " which may be defined as the orientation factor " z ". Hence the observation equation takes the form $v_{12} = -z + a_a - a_o + A_1\, d\varphi_1 + A_2\, d\varphi_2 + B_2\,(d\lambda_2 - d\lambda_1)$ as shown on page 12.

It now remains to eliminate this factor " z " as expeditiously as possible. Two methods are available.

First, we could form the partial normal equations at each Point (see p. 52 for fuller information *re* partial normal equations) and eliminate " z " in the ordinary process of elimination. Such partial normal equations would be of the form:—

z	$\Delta\phi_1$	$\Delta\lambda_1$	$\Delta\phi_2$	$\Delta\lambda_2$	abs.	
n	(a)	(b)	(c)	(d)	(l)	
	(aa)	(ab)	(ac)	(ad)	(al)	I
		(bb)	(bc)	(bd)	(bl)	

where " n " is the number of observation equations at a given point and where the first line of the normal equations is evidently a simple sum of the observation equations at such point. If " z " is now eliminated we would obtain the following set:—

$\Delta\phi$	$\Delta\lambda$	$\Delta\phi$	$\Delta\lambda$	abs.	
$(aa) - (a)\frac{(a)}{n}$	$(ab) - (b)\frac{(a)}{n}$	$(ac) - (c)\frac{(a)}{n}$	$(ad) - (d)\frac{(a)}{n}$	$(al) - (l)\frac{(a)}{n}$	
	$(bb) - (b)\frac{(b)}{n}$	$(bc) - (c)\frac{(b)}{n}$	$(bd) - (d)\frac{(b)}{n}$	$(bl) - (l)\frac{(b)}{n}$	II

The second method of treating the elimination of the " z ", and one which it is believed is preferable, is to employ what is known as a fictitious observation equation and to add it to the body of the original " n " observation equations, thus,—

$\Delta\phi$	$\Delta\lambda$	$\Delta\phi$	$\Delta\lambda$	abs.	
a_1	b_1	c_1	d_1	l_1	III
a_2	b_2	c_2	d_2	l_2	
a_3	b_3	c_3	d_3	l_3	"n" observation equations
$(a)\frac{i}{\sqrt{n}}$	$(b)\frac{i}{\sqrt{n}}$	$(c)\frac{i}{\sqrt{n}}$	$(d)\frac{i}{\sqrt{n}}$	$(l)\frac{i}{\sqrt{n}}$	

where $i = \sqrt{-1}$

It will be seen that this fictitious observation equation is simply the sum equation of the " n " observation equations multiplied throughout by " $\frac{i}{\sqrt{n}}$ " i.e. as if it had a weight $\frac{-i}{n}$

It will also be seen that its inclusion in the original " n " observation equations, III, will give normal equations which will be exactly the same as those in II, in which the " z " is eliminated.

5. *The Normal Equations, partial and collected.*

An examination of any system of normal equations of the form:—

$\Delta\phi_1$	$\Delta\lambda_1$	$\Delta\phi_2$	$\Delta\lambda_2$	abs.
$(aa)_1^n$	(ab)	(ac)	(ad)	(al)
	(bb)	(bc)	(bd)	(bl)
		(cc)	(cd)	(cl)
			(dd)	(dl)

where $(aa)_1^n$ denotes a summation for "n" observation equations and $(aa)_1^n$ could be broken up so that

$$(aa)_1^n = (aa)_1^k + (aa)_{k+1}^1 + \ldots\ldots\ldots (aa)_m^n$$

and where similarly $(ab)_1^n = (ab)_1^k + (al)_{k+1}^1 + \ldots\ldots\ldots (aa)_m^n$

and similarly for other sum terms (aa) . . .

shows that such system could be broken up into a series of partial normal equations, thus:—

the first system of partial normals being formed for observation equations 1 to k

the second system of partial normals being formed for observation equations $k + 1$ to l

and so on, and that the sum of the corresponding terms of these partial normal equations would amount to the corresponding term in the collected normal equations.

Thus each partial set can be formed and checked by itself, which tends to eliminate errors and to promote accuracy and speed.

In our case partial normal equations without a "z" as outlined in the preceding article, were formed and these partials were finally welded together to form the whole collected system.

Nature of Successive Differential Solutions and Comparison of Values obtained.

Successive differential solutions were made:—

(1) To find the effect of the inclusion of the two bases at Coteau and Belleville. These corrections are to be considered as additive to the adjusted values of the φ and λ as given by the adjustment of the nets.
(see p. 25, which nets were conditioned only by being fixed on the United States line Royal to Bellevue.)

(2) To find additional effect of the inclusion of the Ottawa Laplace point. These corrections are to be considered as additive to the values as given by (1).

(3) To find the additional effect of the inclusion of the Murray Laplace point. These corrections are to be considered as additive to the values as given by (2).

Thus the total correction will be the sum of the three corrections as above outlined and which are shown for all the various points of the net on page 25.

For a quick comparison of these three different effects, the following table which is an extract of that given on page 25 is added, where the points included (3) and (42) the westerly and easterly limit of the net and a series of intervening points numbered as shown on page 45.

Point	1st effect		2nd effect		3rd effect		Total		Remarks
	$\Delta\lambda$	$\Delta\phi$	$\Delta\lambda$	$\Delta\phi$	$\Delta\lambda$	$\Delta\phi$			
	due to inclusion of two Bases		due to inclusion of Ottawa Laplace Point		due to inclusion of Murray Laplace Point		$\Delta\lambda$	$\Delta\phi$	
3.....	·038	−·073	·082	·134	·028	·073	·148	·134	
10.....	·028	−·057	·062	·101	·020	·043	·110	·087	
16.....	·023	−·040	·035	·071	·008	·020	·066	·051	
20.....	·023	−·030	·013	·058	·001	·013	·037	·041	
48*.....	·038	−·004	−·099	·040	−·011	−·002	−·072	·034	*(A point on northern spur
24.....	·020	−·016	−·021	·029	−·003	·004	−·004	·017	of net and so mainly
32.....	·005	−·008	−·001	·005	·000	·001	·004	−·002	influenced by Ottawa
42.....	·009	−·001	−·000	−·005	·000	−·001	·009	−·007	Laplace point.)

Conclusions on Twist of the Net

An examination of the preceding table and of the fuller one given on page 25 will show:—

i. The preponderance of the effect (2) over effect (1).
Thus the triangulation was corrected more for twist than for scale, showing the healing effect of Laplace points.

ii. That effect (3) was small between Ottawa and Royal, i.e. the Laplacian correction at Ottawa as given by effect (2) was very near the truth.

iii. That the triangulation, before effects (2) and (3) were applied was heading too far southwards towards lake Ontario, and consequently had to suffer a displacement as outlined by the sums of effect (2) and (3) and which gave all the points in the said triangulation a northerly displacement which might be compared in its effect as a whole to the swinging of the net about the United States Coast and Geodetic line Royal to Bellevue, so that the azimuth of all lines would be increased.

The principle of the successive differential adjustments is easily seen from the following example.

Suppose a system of reduced normal equations in x, y, z, u, and w to be as follows:—

x	y	z	u	w		abs. term	
1	a_1	a_2	a_3	a_4	.....	l_1	
	1	b_2	b_3	b_4	.....	l_2	
		1	c_3	c_4	.....	l_3	System I
			1	d_4	.....	l_4	
				1	.....	l_5	

Omitting the last unknown "w" this system could evidently be broken into two other systems one to determine x_1, y_1, z_1, and u_1, the other a differential system to determine Δx, Δy, Δz, Δu and w, as follows:—

x_1	y_1	z_1	u_1		abs. term	
1	a_1	a_2	a_3	.....	l_1	
	1	b_2	b_3	.....	l_2	System II
		1	c_3	.....	l_3	
			1	.....	l_4	

Δx	Δy	Δz	Δu	w	abs. term	
1	a_1	a_2	a_3	a_4	o	
	1	b_2	b_3	b_4	o	System III
		1	c_3	c_4	o	
			1	d_4	l_4	
				1	l_5	

where the absolute terms in Δx, Δy, Δz and Δu are 0 which amounts to the same thing as taking a differential of each corresponding line of system II.

Evidently final $x = x_1 + \Delta x$, and similarly for other terms.

By this method a number of backward solutions were made but with this advantage that all the terms in the body of each differential backward solution were necessarily small and decreased in effect as the solution proceeded towards the left. The reduction of labour and a tendency towards accuracy by use of small numbers is obtained at the same time the particular differential effect is ascertained.

Accuracy of the Adjustment

The accuracy of any adjustment is determined not only by the size of the net, i.e., the number of observations in that net, but is also indicated by examining how closely the adjusted values agree with the observed ones.

The first criterion amounts in fact to saying that for an ideal adjustment *all* the observations should be included so that in determining the maximum function (vv) such function should refer to the whole system. In our case something like 275 observations were included and on account of the complexity of the net and its great width in comparison with its length, it was felt that it would be very laborious to enlarge the system much beyond its present dimensions.

As regards the satisfaction of the absolute terms of the normal equations which really shows how closely the adjusted values fulfil the condition, we note as follows:—

Equation	Absolute term observed	Absolute term computed
	"	"
Laplacian Murray-Grimsthorpe	4·705	4·701
Laplacian Murray-Asphodel	5·377	5·372
Laplacian Ottawa-King Mountain	3·032	3·029
Laplacian Ottawa-Wakefield	4·243	4·233
Length, Belleville Base	−0·0557	−0·0522
Length, Coteau Base	−0·0672	−0·0625

Probably the best test of the accuracy of the adjustment is the examination of the condition that the sum of the v's, the corrections to the observations, about a point ought to be zero.

This condition, while a little difficult to prove in a conditional adjustment, at once follows from a co-ordinate adjustment by considering the fact that $(av) = 0$ which reduces to $(v) = 0$ where the "a"s are coefficients of the "z" at a particular point and are, as is seen by an examination of the observational equations on page 21, all equal to unity.

Before the v's were computed and hence before their sum about a point could be known, the "z" at each point was determined from the "sum" equation, see page 52, by substituting the $\Delta\phi$'s and $\Delta\lambda$'s in such sum equation. Knowing the "z" and operating on each observational equation the v's could be easily determined, whose summation about a point, is illustrated by the following table, which is illustrative for a few selected points.

Point	Number of directions at point	Sum of v's about such point
4	9	+0·0001
8	11	+0·0022
16	6	−0·0008
21	8	+0·0005
27	8	+0·0017
35	10	−0·0004
41	5	−0·0005

For a tabulation of the observations and their adjusted values see page 27.
For a tabulation of the adjusted angles of certain triangles see page 32.

The Precisions

The objects of finding the precisions of parts of the net are threefold,—

1st. To find the strength of external parts, e.g. sides of the triangulation which are to be used as bases for new triangulation.

2nd. To find the probable error of the position of a point in ϕ or λ which may in the future be used as a check point for a secondary triangulation.

3rd. To analyse in concrete figures what the particular triangulation is doing as regards probable twist and probable scale error.

Such precisions, as here determined, are:—

(1) The probable error of a direction,—

Here "n" number of observations, being 276
" "m" " observation co-ordinates 141
" "q" " conditions 6

we have $r = 0.6745 \left(\frac{(vv)}{n-m+q}\right)^{\frac{1}{2}}$

$= 0.432$

(2) The probable error of a function of the adjusted values.

This demands that we find the reciprocal of the square of the weight of such function.

Theory says that such weight functions are to be placed at the *end* of the normal equations and evaluated by means of the normal equations, as shown by the following scheme:—

$\Delta\phi$	$\Delta\lambda$	$\Delta\phi \cdot \Delta\lambda$...	K	K	
(aa)	(ab)	(ac).....	p_1	q_1	F_1
	(bb)	(bc).....	p_2	q_2	F_2
		(cc).....	p_3	q_3	F_3

a form to show how the function "$F_1\Delta\phi_1 + F_2\Delta\lambda_1 + F_3\Delta\phi_2$" is to be placed. See page 57 for concrete case.

The final evaluation is according to the formula

$$\mu^2_F = \mu^2 \left[\frac{F_1^2}{(aa)} + \frac{(F_2 \cdot 1)^2}{(bb \cdot 1)} + \frac{(F_3 \cdot 2)^2}{(cc \cdot 2)} \cdots \right] - \frac{(F_4 \cdot 3)^2}{(pp)} - \frac{(F_5 \cdot 4)^2}{(qq \cdot 1)}$$

As a particular application of this theory to our net, the precisions were determined of:—

(*a*) ϕ and λ of point 27
ϕ " λ " 42
ϕ " λ " 40
ϕ " λ " 15
ϕ " λ " 44
ϕ " λ " 4
ϕ " λ " 1

(*b*) line joining points 42 and 48 and designated briefly 42–48*
" " " 42 " 41 " " " 42–41
" " " 41 " 40 " " " 41–40
" " " 26 " 30 " " " 26–30
" " " 47 " 48 " " " 47–48
" " " 18 " 19 " " " 18–19
" " " 1 " 9 " " " 1– 9
" " " 42 " 3 " " " 42– 3*
" " " 2 " 3 " " " 2– 3

(*c*) direction of lines joining points 41 and 36 and designated briefly (41–36)
" " " " " 30 " 26 " " " (30–26)
" " " " " 49 " 21 " " " (49–21)
" " " " " 47 " 44 " " " (47–44)
" " " " " 20 " 15 " " " (20–15)
" " " " " 13 " 9 " " " (13– 9)
" " " " " 4 " 2 " " " (4– 2)

where in each case the initial number denotes station at which observations took place, thus for (41–36) the observations took place at station 41.

The following table gives the probable error in ϕ and λ of a series of points ranging from the easterly limit of the net to its westerly limit:—

Point	P. E. in ϕ	P. E. in λ
42	±0·007	±0·007
40	±0·003	±0·004
27	±0·003	±0·013
44	±0·006	±0·019
15	±0·008	±0·023
4	±0·014	±0·027
1	±0·014	±0·032

The probable errors are thus small and well under the size of the systematic error of twist as corrected by the Laplace points at Ottawa and Murray. (*See* p. 25 for the correction due to such points).

The following table gives the probable error of some external sides of the triangulation as well as of two " hypothetical lines ":—

Line	P. E. in metres	Ratio P. E. to a side	Remarks
42–41	±0·232	1 in 383000	
41–40	±0·126	1 in 361000	
26–30	±0·106	1 in 287000	
47–48	±0·229	1 in 150000	
18–19	±0·136	1 in 234000	
1– 9	±0·148	1 in 315000	
2– 3	±0·078	1 in 428000	
42–48	±0·384	1 in 527000	A hypothetical cross-line
42– 3	±0·864	1 in 519000	A hypothetical cross-line

*Particular attention is directed to the two lines, cross country lines 42-48 and 42-3.

Thus the probable error of a line running the whole length of the triangulation was only 0.864 metres. The probable error of any other side could be found by a similar process to that given on page 59 where u = reciprocal of square of weight, was evaluated.

The following table shows the probable error of the corrections to some of the observed directions.

Direction	Probable Error
	"
41–36	±0·223
30–26	±0·341
44–21	±0·174
47–44	±0·161
20–15	±0·359
13– 9	±0·300
4– 2	±0·165

All these probable errors are within the limits ±0.432, the probable error of an observation.

OBSERVATION EQUATIONS*

DUSABLE-HALDIMAND NET

	STATION METHUEN—																
$v_{1.2}$	=	−	z_1				+ 52,372	$\delta\varphi_1$	− 162,499	$\delta\lambda_1$	− 52,156	$\delta\varphi_2$	+ 162,499	$\delta\lambda_2$		0,000
$v_{1.9}$	=	−	z_1				+ 134,153	$\delta\varphi_1$	+ 16,833	$\delta\lambda_1$	− 134,326	$\delta\varphi_9$	− 16,833	$\delta\lambda_9$	−	0,843
$v_{1.8}$	=	−	z_1				+ 75,290	$\delta\varphi_1$	− 61,650	$\delta\lambda_1$	− 74,800	$\delta\varphi_8$	+ 61,650	$\delta\lambda_8$	−	0,316
	STATION ASPHODEL—																
$v_{2.1}$	=	−	z_2	+ 52,372	$\delta\varphi_1$	− 161,798	$\delta\lambda_1$	− 52,156	$\delta\varphi_2$	+ 161,798	$\delta\lambda_2$						0,000
$v_{2.9}$	=	−	z_2					+ 90,112	$\delta\varphi_2$	+ 56,208	$\delta\lambda_2$	− 90,603	$\delta\varphi_9$	− 56,208	$\delta\lambda_9$	+	$1,03_7$
$v_{2.8}$	=	−	z_2					+ 165,686	$\delta\varphi_2$	− 59,692	$\delta\lambda_2$	− 165,292	$\delta\varphi_8$	+ 59,692	$\delta\lambda_8$	+	$0,90_2$
$v_{2.4}$	=	−	z_2					+ 99,983	$\delta\varphi_2$	− 104,249	$\delta\lambda_2$	− 99,524	$\delta\varphi_4$	+ 104,249	$\delta\lambda_4$	+	$1,09_2$
$v_{2.3}$	=	−	z_2					− 69,246	$\delta\varphi_2$	− 127,881	$\delta\lambda_2$	+ 68,914	$\delta\varphi_3$	+ 127,881	$\delta\lambda_3$	+	$0,98_6$
	STATION HALDIMAND—																
$v_{3.2}$	=	−	z_3	− 69,246	$\delta\varphi_2$	− 127,183	$\delta\lambda_2$	+ 68,914	$\delta\varphi_3$	+ 127,183	$\delta\lambda_3$						$0,00_0$
$v_{3.8}$	=	−	z_3					+ 130,305	$\delta\varphi_3$	+ 34,099	$\delta\lambda_3$	− 130,621	$\delta\varphi_8$	− 34,099	$\delta\lambda_8$	−	$0,34_4$
$v_{3.4}$	=	−	z_3					+ 193,791	$\delta\varphi_3$	+ 5,293	$\delta\lambda_3$	− 193,830	$\delta\varphi_4$	− 5,293	$\delta\lambda_4$	−	$0,49_3$
	STATION MURRAY—																
$v_{4.9}$	=	−	z_4					+ 26,959	$\delta\varphi_4$	+ 64,287	$\delta\lambda_4$	− 27,231	$\delta\varphi_9$	− 64,287	$\delta\lambda_9$		$0,00_0$
$v_{4.8}$	=	−	z_4					+ 207,574	$\delta\varphi_4$	+ 210,549	$\delta\lambda_4$	− 208,036	$\delta\varphi_8$	− 210,549	$\delta\lambda_8$	−	$0,22_2$
$v_{4.10}$	=	−	z_4					+ 121,967	$\delta\varphi_4$	+ 55,459	$\delta\lambda_4$	− 122,410	$\delta\varphi_{10}$	− 55,459	$\delta\lambda_{10}$	−	$0,18_8$
$v_{4.6}$	=	−	z_4					+ 270,508	$\delta\varphi_4$	+ 54,516	$\delta\lambda_4$	− 270,763	$\delta\varphi_6$	− 54,516	$\delta\lambda_6$	−	$0,37_7$
$v_{4.5}$	=	−	z_4					+ 674,432	$\delta\varphi_4$	+ 105,079	$\delta\lambda_4$	− 674,635	$\delta\varphi_5$	− 105,079	$\delta\lambda_5$	−	$1,17_5$
$v_{4.11}$	=	−	z_4					+ 135,328	$\delta\varphi_4$	− 22,012	$\delta\lambda_4$	− 135,122	$\delta\varphi_{11}$	+ 22,012	$\delta\lambda_{11}$	+	$0,23_0$
$v_{4.7}$	=	−	z_4					+ 280,610	$\delta\varphi_4$	− 90,663	$\delta\lambda_4$	− 280,247	$\delta\varphi_7$	+ 90,663	$\delta\lambda_7$	−	$0,37_4$
$v_{4.3}$	=	−	z_4	+ 193,791	$\delta\varphi_3$	+ 5,989	$\delta\lambda_3$	− 193,830	$\delta\varphi_4$	− 5,989	$\delta\lambda_4$					+	$0,43_1$
$v_{4.2}$	=	−	z_4	+ 99,983	$\delta\varphi_2$	− 103,551	$\delta\lambda_2$	− 99,524	$\delta\varphi_4$	+ 103,551	$\delta\lambda_4$					−	$0,38_2$
	STATION WEST BASE—																
$v_{5.4}$	=	−	z_5	+ 674,432	$\delta\varphi_4$	+ 105,775	$\delta\lambda_4$	− 674,635	$\delta\varphi_5$	− 105,775	$\delta\lambda_5$						0,000
$v_{5.8}$	=	−	z_5					+ 50,133	$\delta\varphi_5$	+ 362,516	$\delta\lambda_5$	− 50,230	$\delta\varphi_8$	− 362,516	$\delta\lambda_8$	+	2,021
$v_{5.6}$	=	−	z_5					+ 449,760	$\delta\varphi_5$	+ 105,581	$\delta\lambda_5$	− 450,049	$\delta\varphi_6$	− 105,581	$\delta\lambda_6$	+	1,493
$v_{5.11}$	=	−	z_5					+ 160,083	$\delta\varphi_5$	− 38,713	$\delta\lambda_5$	− 159,791	$\delta\varphi_{11}$	+ 38,713	$\delta\lambda_{11}$	+	2,276
$v_{5.7}$	=	−	z_5					+ 305,604	$\delta\varphi_5$	− 231,746	$\delta\lambda_5$	− 305,117	$\delta\varphi_7$	+ 231,746	$\delta\lambda_7$	+	0,689
	STATION EAST BASE—																
$v_{6.4}$	=	−	z_6	+ 270,508	$\delta\varphi_4$	+ 55,213	$\delta\lambda_4$	− 270,763	$\delta\varphi_6$	− 55,213	$\delta\lambda_6$						0,000
$v_{6.8}$	=	−	z_6					− 362,934	$\delta\varphi_6$	+ 188,132	$\delta\lambda_6$	+ 363,399	$\delta\varphi_8$	− 188,132	$\delta\lambda_8$	−	0,476
$v_{6.11}$	=	−	z_6					+ 185,866	$\delta\varphi_6$	− 93,899	$\delta\lambda_6$	− 185,408	$\delta\varphi_{11}$	+ 93,899	$\delta\lambda_{11}$	+	0,378
$v_{6.7}$	=	−	z_6					− 83,360	$\delta\varphi_6$	− 302,795	$\delta\lambda_6$	+ 83,174	$\delta\varphi_7$	+ 302,795	$\delta\lambda_7$	+	0,183
$v_{6.5}$	=	−	z_6	+ 449,760	$\delta\varphi_5$	+ 106,277	$\delta\lambda_5$	− 450,049	$\delta\varphi_6$	− 106,277	$\delta\lambda_6$					+	0,911
	AMELIASBURG—																
$v_{7.4}$	=	−	z_7	+ 280,610	$\delta\varphi_4$	− 89,968	$\delta\lambda_4$	− 280,247	$\delta\varphi_7$	+ 89,968	$\delta\lambda_7$						0,000
$v_{7.5}$	=	−	z_7	+ 305,604	$\delta\varphi_5$	− 231,050	$\delta\lambda_5$	− 305,117	$\delta\varphi_7$	+ 231,050	$\delta\lambda_7$					−	0,215
$v_{7.8}$	=	−	z_7					− 91,650	$\delta\varphi_7$	+ 174,783	$\delta\lambda_7$	+ 91,973	$\delta\varphi_8$	− 174,783	$\delta\lambda_8$	−	0,145
$v_{7.6}$	=	−	z_7	− 83,360	$\delta\varphi_6$	− 302,099	$\delta\lambda_6$	+ 83,174	$\delta\varphi_7$	+ 302,099	$\delta\lambda_7$					+	0,663
$v_{7.10}$	=	−	z_7					+ 85,280	$\delta\varphi_7$	+ 107,581	$\delta\lambda_7$	− 85,701	$\delta\varphi_{10}$	− 107,581	$\delta\lambda_{10}$	+	1,018
$v_{7.11}$	=	−	z_7					+ 244,488	$\delta\varphi_7$	− 10,639	$\delta\lambda_7$	− 244,431	$\delta\varphi_{11}$	+ 10,639	$\delta\lambda_{11}$	+	1,100

*See, for fuller information on this correction, Helmert's Geodesy, p. 189, Crandall p. 169, Jordan III, p. 390.
*Particular attention is directed to the two lines, cross country lines 42–48 and 42–3.
*For the derivation formulae of these observation equations see p. 12.
*The symbol 1.2 denotes the direction from station 1 to station 2.

OBSERVATION EQUATIONS—*Continued*

DUSABLE-HALDIMAND NET—*Continued*

Station Oak Hill—

$v_{8.4} = -z_8 + 207{,}574\,\delta\varphi_4 + 211{,}246\,\delta\lambda_4 - 208{,}036\,\delta\varphi_8 - 211{,}246\,\delta\lambda_8$ 0,000
$v_{8.3} = -z_8 + 130{,}305\,\delta\varphi_3 + 34{,}796\,\delta\lambda_3 - 130{,}621\,\delta\varphi_8 - 34{,}796\,\delta\lambda_8 + 0{,}451$
$v_{8.2} = -z_8 + 165{,}686\,\delta\varphi_2 - 58{,}994\,\delta\lambda_2 - 165{,}292\,\delta\varphi_8 + 58{,}994\,\delta\lambda_8 - 0{,}011$
$v_{8.1} = -z_8 + 75{,}290\,\delta\varphi_1 - 60{,}950\,\delta\lambda_1 - 74{,}800\,\delta\varphi_8 + 60{,}950\,\delta\lambda_8 + 0{,}138$
$v_{8.9} = -z_8 + 22{,}397\,\delta\varphi_8 + 87{,}318\,\delta\lambda_8 - 22{,}572\,\delta\varphi_9 - 87{,}318\,\delta\lambda_9 + 0{,}567$
$v_{8.13} = -z_8 + 69{,}657\,\delta\varphi_8 + 69{,}369\,\delta\lambda_8 - 70{,}125\,\delta\varphi_{13} - 69{,}369\,\delta\lambda_{13} + 1{,}428$
$v_{8.10} = -z_8 + 212{,}384\,\delta\varphi_8 + 51{,}530\,\delta\lambda_8 - 212{,}684\,\delta\varphi_{10} - 51{,}530\,\delta\lambda_{10} + 0{,}162$
$v_{8.11} = -z_8 + 123{,}084\,\delta\varphi_8 - 62{,}877\,\delta\lambda_8 - 122{,}623\,\delta\varphi_{11} + 62{,}877\,\delta\lambda_{11} + 1{,}565$
$v_{8.6} = -z_8 - 362{,}934\,\delta\varphi_6 + 188{,}829\,\delta\lambda_6 + 363{,}399\,\delta\varphi_8 - 188{,}829\,\delta\lambda_8 + 0{,}191$
$v_{8.7} = -z_8 - 91{,}650\,\delta\varphi_7 + 175{,}480\,\delta\lambda_7 + 91{,}973\,\delta\varphi_8 - 175{,}480\,\delta\lambda_8 + 0{,}219$
$v_{8.5} = -z_8 + 50{,}133\,\delta\varphi_5 + 363{,}213\,\delta\lambda_5 - 50{,}230\,\delta\varphi_8 - 363{,}213\,\delta\lambda_8 + 1{,}175$

Station Grimsthorpe—

$v_{9.14} = -z_9 + 137{,}003\,\delta\varphi_9 + 8{,}051\,\delta\lambda_9 - 137{,}088\,\delta\varphi_{14} - 8{,}051\,\delta\lambda_{14}$ 0,000
$v_{9.13} = -z_9 + 265{,}198\,\delta\varphi_9 - 62{,}667\,\delta\lambda_9 - 264{,}902\,\delta\varphi_{13} + 62{,}667\,\delta\lambda_{13} + 0{,}546$
$v_{9.10} = -z_9 + 55{,}891\,\delta\varphi_9 - 94{,}023\,\delta\lambda_9 - 55{,}534\,\delta\varphi_{10} + 94{,}023\,\delta\lambda_{10} - 0{,}291$
$v_{9.8} = -z_9 + 22{,}397\,\delta\varphi_8 + 88{,}019\,\delta\lambda_8 - 22{,}572\,\delta\varphi_9 - 88{,}019\,\delta\lambda_9 + 0{,}227$
$v_{9.4} = -z_9 + 26{,}959\,\delta\varphi_4 + 64{,}987\,\delta\lambda_4 - 27{,}231\,\delta\varphi_9 - 64{,}987\,\delta\lambda_9 + 0{,}133$
$v_{9.2} = -z_9 + 90{,}112\,\delta\varphi_2 + 56{,}909\,\delta\lambda_2 - 90{,}603\,\delta\varphi_9 - 56{,}909\,\delta\lambda_9 - 0{,}134$
$v_{9.1} = -z_9 + 134{,}153\,\delta\varphi_1 + 17{,}536\,\delta\lambda_1 - 134{,}326\,\delta\varphi_9 - 17{,}536\,\delta\lambda_9 + 0{,}384$

Station Tyendinaga—

$v_{10.13} = -z_{10} + 22{,}721\,\delta\varphi_{10} + 131{,}549\,\delta\lambda_{10} - 22{,}842\,\delta\varphi_{13} - 131{,}549\,\delta\lambda_{13}$ 0,000
$v_{10.12} = -z_{10} + 134{,}128\,\delta\varphi_{10} + 23{,}065\,\delta\lambda_{10} - 134{,}354\,\delta\varphi_{12} - 23{,}065\,\delta\lambda_{12} - 0{,}330$
$v_{10.11} = -z_{10} + 41{,}136\,\delta\varphi_{10} - 130{,}183\,\delta\lambda_{10} - 40{,}924\,\delta\varphi_{11} + 130{,}183\,\delta\lambda_{11} - 0{,}005$
$v_{10.7} = -z_{10} + 85{,}280\,\delta\varphi_7 + 108{,}278\,\delta\lambda_7 - 85{,}701\,\delta\varphi_{10} - 108{,}278\,\delta\lambda_{10} + 1{,}647$
$v_{10.4} = -z_{10} + 121{,}967\,\delta\varphi_4 + 56{,}157\,\delta\lambda_4 - 122{,}410\,\delta\varphi_{10} - 56{,}157\,\delta\lambda_{10} + 0{,}340$
$v_{10.8} = -z_{10} + 212{,}384\,\delta\varphi_8 + 52{,}228\,\delta\lambda_8 - 212{,}684\,\delta\varphi_{10} - 52{,}228\,\delta\lambda_{10} + 0{,}527$
$v_{10.9} = -z_{10} + 55{,}891\,\delta\varphi_9 - 93{,}322\,\delta\lambda_9 - 55{,}534\,\delta\varphi_{10} + 93{,}322\,\delta\lambda_{10} + 0{,}063$

Station Hallowell—

$v_{11.4} = -z_{11} + 135{,}328\,\delta\varphi_4 - 21{,}316\,\delta\lambda_4 - 135{,}122\,\delta\varphi_{11} + 21{,}316\,\delta\lambda_{11}$ 0,000
$v_{11.5} = -z_{11} + 160{,}083\,\delta\varphi_5 - 38{,}017\,\delta\lambda_5 - 159{,}791\,\delta\varphi_{11} + 38{,}017\,\delta\lambda_{11} + 0{,}398$
$v_{11.6} = -z_{11} + 185{,}866\,\delta\varphi_6 - 93{,}203\,\delta\lambda_6 - 185{,}408\,\delta\varphi_{11} + 93{,}203\,\delta\lambda_{11} - 0{,}165$
$v_{11.8} = -z_{11} + 123{,}084\,\delta\varphi_8 - 62{,}181\,\delta\lambda_8 - 122{,}623\,\delta\varphi_{11} + 62{,}181\,\delta\lambda_{11} - 0{,}016$
$v_{11.10} = -z_{11} + 41{,}135\,\delta\varphi_{10} - 129{,}486\,\delta\lambda_{10} - 40{,}924\,\delta\varphi_{11} + 129{,}486\,\delta\lambda_{11} + 0{,}201$
$v_{11.12} = -z_{11} + 70{,}291\,\delta\varphi_{11} + 60{,}124\,\delta\lambda_{11} - 70{,}774\,\delta\varphi_{12} - 60{,}124\,\delta\lambda_{12} + 0{,}477$
$v_{11.7} = -z_{11} + 244{,}488\,\delta\varphi_7 - 9{,}944\,\delta\lambda_7 - 244{,}431\,\delta\varphi_{11} + 9{,}944\,\delta\lambda_{11} + 0{,}727$

Station Portland—

$v_{12.16} = -z_{12} + 97{,}315\,\delta\varphi_{12} + 120{,}352\,\delta\lambda_{12} - 97{,}744\,\delta\varphi_{16} - 120{,}352\,\delta\lambda_{16}$ 0,000
$v_{12.18} = -z_{12} + 122{,}567\,\delta\varphi_{12} + 11{,}358\,\delta\lambda_{12} - 122{,}696\,\delta\varphi_{18} - 11{,}358\,\delta\lambda_{18} + 0{,}091$
$v_{12.11} = -z_{12} + 70{,}291\,\delta\varphi_{11} + 60{,}821\,\delta\lambda_{11} - 70{,}774\,\delta\varphi_{12} - 60{,}821\,\delta\lambda_{12} + 0{,}083$
$v_{12.10} = -z_{12} + 134{,}128\,\delta\varphi_{10} + 23{,}764\,\delta\lambda_{10} - 134{,}354\,\delta\varphi_{12} - 23{,}764\,\delta\lambda_{12} + 0{,}062$
$v_{12.13} = -z_{12} - 118{,}357\,\delta\varphi_{12} + 48{,}165\,\delta\lambda_{12} + 118{,}784\,\delta\varphi_{13} - 48{,}165\,\delta\lambda_{13} + 0{,}159$
$v_{12.14} = -z_{12} - 70{,}803\,\delta\varphi_{12} + 108{,}949\,\delta\lambda_{12} + 71{,}182\,\delta\varphi_{14} - 108{,}949\,\delta\lambda_{14} + 0{,}568$

Station Kaladar—

$v_{13.10} = -z_{13} + 22{,}721\,\delta\varphi_{10} + 132{,}250\,\delta\lambda_{10} - 22{,}842\,\delta\varphi_{13} - 132{,}250\,\delta\lambda_{13}$ 0,000
$v_{13.8} = -z_{13} + 69{,}657\,\delta\varphi_8 + 70{,}069\,\delta\lambda_8 - 70{,}125\,\delta\varphi_{13} - 70{,}069\,\delta\lambda_{13} + 0{,}765$
$v_{13.9} = -z_{13} + 265{,}198\,\delta\varphi_9 - 61{,}964\,\delta\lambda_9 - 264{,}902\,\delta\varphi_{13} + 61{,}964\,\delta\lambda_{13} - 0{,}036$
$v_{13.15} = -z_{13} + 69{,}583\,\delta\varphi_{13} + 58{,}672\,\delta\lambda_{13} - 70{,}076\,\delta\varphi_{15} - 58{,}672\,\delta\lambda_{15} - 0{,}145$
$v_{13.14} = -z_{13} + 215{,}504\,\delta\varphi_{13} + 69{,}450\,\delta\lambda_{13} - 215{,}878\,\delta\varphi_{14} - 69{,}450\,\delta\lambda_{14} + 0{,}509$
$v_{13.12} = -z_{13} - 118{,}357\,\delta\varphi_{12} + 48{,}867\,\delta\lambda_{12} + 118{,}784\,\delta\varphi_{13} - 48{,}867\,\delta\lambda_{13} - 0{,}257$

Station Olden—

$v_{14.12} = -z_{14} - 70{,}803\,\delta\varphi_{12} + 109{,}651\,\delta\lambda_{12} + 71{,}182\,\delta\varphi_{14} - 109{,}651\,\delta\lambda_{14}$ 0,000
$v_{14.13} = -z_{14} + 215{,}504\,\delta\varphi_{13} + 70{,}154\,\delta\lambda_{13} - 215{,}878\,\delta\varphi_{14} - 70{,}154\,\delta\lambda_{14} + 1{,}231$
$v_{14.9} = -z_{14} + 137{,}003\,\delta\varphi_9 + 8{,}755\,\delta\lambda_9 - 137{,}088\,\delta\varphi_{14} - 8{,}755\,\delta\lambda_{14} + 0{,}267$
$v_{14.15} = -z_{14} + 64{,}253\,\delta\varphi_{14} + 115{,}367\,\delta\lambda_{14} - 64{,}596\,\delta\varphi_{15} - 115{,}367\,\delta\lambda_{15} + 0{,}940$
$v_{14.16} = -z_{14} + 191{,}493\,\delta\varphi_{14} - 25{,}705\,\delta\lambda_{14} - 191{,}314\,\delta\varphi_{16} + 25{,}705\,\delta\lambda_{16} - 0{,}023$

Station Lavant—

$v_{15.16} = -z_{15} + 61{,}755\,\delta\varphi_{15} - 93{,}600\,\delta\lambda_{15} - 61{,}370\,\delta\varphi_{16} + 93{,}600\,\delta\lambda_{16}$ 0,000
$v_{15.14} = -z_{15} + 64{,}253\,\delta\varphi_{14} + 116{,}073\,\delta\lambda_{14} - 64{,}596\,\delta\varphi_{15} - 116{,}073\,\delta\lambda_{15} + 0{,}733$
$v_{15.13} = -z_{15} + 69{,}583\,\delta\varphi_{13} + 59{,}378\,\delta\lambda_{13} - 70{,}076\,\delta\varphi_{15} - 59{,}378\,\delta\lambda_{15} - 0{,}132$
$v_{15.21} = -z_{15} + 62{,}383\,\delta\varphi_{15} + 34{,}120\,\delta\lambda_{15} - 62{,}876\,\delta\varphi_{21} - 34{,}120\,\delta\lambda_{21} + 0{,}081$
$v_{15.20} = -z_{15} + 137{,}048\,\delta\varphi_{15} - 20{,}284\,\delta\lambda_{15} - 136{,}850\,\delta\varphi_{20} + 20{,}285\,\delta\lambda_{20} + 0{,}799$
$v_{15.17} = -z_{15} + 79{,}028\,\delta\varphi_{15} - 49{,}226\,\delta\lambda_{15} - 78{,}532\,\delta\varphi_{17} + 49{,}226\,\delta\lambda_{17} + 0{,}813$

Station North Crosby—

$v_{16.17} = -z_{16} + 233{,}211\,\delta\varphi_{16} - 1{,}861\,\delta\lambda_{16} - 233{,}202\,\delta\varphi_{17} + 1{,}861\,\delta\lambda_{17}$ 0,000
$v_{16.18} = -z_{16} + 133{,}105\,\delta\varphi_{16} - 59{,}337\,\delta\lambda_{16} - 132{,}660\,\delta\varphi_{18} + 59{,}337\,\delta\lambda_{18} + 0{,}351$
$v_{16.12} = -z_{16} + 97{,}315\,\delta\varphi_{12} + 121{,}054\,\delta\lambda_{12} - 97{,}744\,\delta\varphi_{16} - 121{,}054\,\delta\lambda_{16} + 1{,}121$
$v_{16.14} = -z_{16} + 191{,}493\,\delta\varphi_{14} - 25{,}002\,\delta\lambda_{14} - 191{,}314\,\delta\varphi_{16} + 25{,}002\,\delta\lambda_{16} + 1{,}009$
$v_{16.15} = -z_{16} + 61{,}755\,\delta\varphi_{15} - 92{,}894\,\delta\lambda_{15} - 61{,}370\,\delta\varphi_{16} + 92{,}894\,\delta\lambda_{16} - 0{,}173$
$v_{16.20} = -z_{16} + 102{,}319\,\delta\varphi_{16} + 85{,}463\,\delta\lambda_{16} - 102{,}813\,\delta\varphi_{20} - 85{,}463\,\delta\lambda_{20} + 1{,}431$

Station Bastard—

$v_{17.16} = -z_{17} + 233{,}211\,\delta\varphi_{16} - 1{,}158\,\delta\lambda_{16} - 233{,}202\,\delta\varphi_{17} + 1{,}158\,\delta\lambda_{17}$ 0,000
$v_{17.15} = -z_{17} + 79{,}028\,\delta\varphi_{15} - 48{,}521\,\delta\lambda_{15} - 78{,}532\,\delta\varphi_{17} + 48{,}521\,\delta\lambda_{17}$ 0,266
$v_{17.20} = -z_{17} - 7{,}807\,\delta\varphi_{17} + 146{,}157\,\delta\lambda_{17} + 7{,}845\,\delta\varphi_{20} - 146{,}157\,\delta\lambda_{20} - 0{,}970$
$v_{17.19} = -z_{17} + 209{,}356\,\delta\varphi_{17} + 1{,}995\,\delta\lambda_{17} - 209{,}372\,\delta\varphi_{19} - 1{,}995\,\delta\lambda_{19} + 0{,}294$
$v_{17.18} = -z_{17} + 91{,}668\,\delta\varphi_{17} - 192{,}408\,\delta\lambda_{17} - 91{,}365\,\delta\varphi_{18} + 192{,}408\,\delta\lambda_{18} - 0{,}033$

Station Lansdowne—

$v_{18.19} = -z_{18} + 146{,}078\,\delta\varphi_{18} + 97{,}373\,\delta\lambda_{18} - 146{,}573\,\delta\varphi_{19} - 97{,}373\,\delta\lambda_{19}$ 0,000
$v_{18.12} = -z_{18} + 122{,}567\,\delta\varphi_{12} + 12{,}058\,\delta\lambda_{12} - 122{,}696\,\delta\varphi_{18} - 12{,}058\,\delta\lambda_{18} - 0{,}823$
$v_{18.16} = -z_{18} + 133{,}105\,\delta\varphi_{16} - 58{,}635\,\delta\lambda_{16} - 132{,}660\,\delta\varphi_{18} + 58{,}635\,\delta\lambda_{18} - 0{,}806$
$v_{18.17} = -z_{18} + 91{,}668\,\delta\varphi_{17} - 191{,}706\,\delta\lambda_{17} - 91{,}365\,\delta\varphi_{18} + 191{,}706\,\delta\lambda_{18} - 1{,}424$

Station Elizabethtown—

$v_{19.17} = -z_{19} + 209{,}356\,\delta\varphi_{17} + 2{,}698\,\delta\lambda_{17} - 209{,}372\,\delta\varphi_{19} - 2{,}698\,\delta\lambda_{19}$ 0,000
$v_{19.20} = -z_{19} - 104{,}382\,\delta\varphi_{19} + 71{,}518\,\delta\lambda_{19} + 104{,}882\,\delta\varphi_{20} - 71{,}518\,\delta\lambda_{20} + 0{,}728$
$v_{19.22} = -z_{19} + 40{,}619\,\delta\varphi_{19} + 98{,}349\,\delta\lambda_{19} - 40{,}890\,\delta\varphi_{22} - 98{,}349\,\delta\lambda_{22} + 0{,}369$
$v_{19.18} = -z_{19} + 146{,}078\,\delta\varphi_{18} + 98{,}075\,\delta\lambda_{18} - 146{,}574\,\delta\varphi_{19} - 98{,}075\,\delta\lambda_{19} + 0{,}901$

OBSERVATION EQUATIONS—*Continued*

DUSABLE-HALDIMAND NET—*Continued*

Station Elmsley—

$v_{20.21} = -z_{20} + 31{,}669\,\delta\varphi_{20} + 69{,}382\,\delta\lambda_{20} - 31{,}965\,\delta\varphi_{21} - 69{,}382\,\delta\lambda_{21} - 0{,}000$

$v_{20.22} = -z_{20} + 135{,}462\,\delta\varphi_{20} + 25{,}620\,\delta\lambda_{20} - 135{,}715\,\delta\varphi_{22} - 25{,}620\,\delta\lambda_{22} - 0{,}852$

$v_{20.19} = -z_{20} - 104{,}382\,\delta\varphi_{19} + 72{,}222\,\delta\lambda_{19} + 104{,}882\,\delta\varphi_{20} - 72{,}222\,\delta\lambda_{20} - 0{,}174$

$v_{20.17} = -z_{20} - 7{,}807\,\delta\varphi_{17} + 146{,}862\,\delta\lambda_{17} + 7{,}845\,\delta\varphi_{20} - 146{,}862\,\delta\lambda_{20} - 0{,}751$

$v_{20.16} = -z_{20} + 102{,}319\,\delta\varphi_{16} + 86{,}168\,\delta\lambda_{16} - 102{,}813\,\delta\varphi_{20} - 86{,}168\,\delta\lambda_{20} - 0{,}249$

$v_{20.15} = -z_{20} + 137{,}048\,\delta\varphi_{15} - 19{,}577\,\delta\lambda_{15} - 136{,}850\,\delta\varphi_{20} + 19{,}577\,\delta\lambda_{20} - 0{,}490$

Station King Mountain—

$v_{21.25} = -z_{21} + 152{,}962\,\delta\varphi_{21} + 48{,}487\,\delta\lambda_{21} - 153{,}348\,\delta\varphi_{25} - 48{,}487\,\delta\lambda_{25} 0{,}000$

$v_{21.26} = -z_{21} + 100{,}801\,\delta\varphi_{21} + 1{,}185\,\delta\lambda_{21} - 100{,}823\,\delta\varphi_{26} - 1{,}185\,\delta\lambda_{26} + 1{,}540$

$v_{21.24} = -z_{21} + 169{,}399\,\delta\varphi_{21} - 19{,}841\,\text{E}\lambda_{21} - 169{,}236\,\delta\varphi_{24} + 19{,}841\,\delta\lambda_{24} + 0{,}660$

$v_{21.23} = -z_{21} + 80{,}059\,\delta\varphi_{21} - 25{,}528\,\delta\lambda_{21} - 79{,}680\,\delta\varphi_{23} + 25{,}528\,\delta\lambda_{23} + 0{,}860$

$v_{21.49} = -z_{21} + 298{,}481\,\delta\varphi_{21} - 191{,}770\,\delta\lambda_{21} - 297{,}972\,\delta\varphi_{49} + 191{,}770\,\delta\lambda_{49} + 0{,}136$

$v_{21.22} = -z_{21} + 56{,}746\,\delta\varphi_{21} - 75{,}589\,\delta\lambda_{21} - 56{,}325\,\delta\varphi_{22} + 75{,}589\,\delta\lambda_{22} + 0{,}211$

$v_{21.20} = -z_{21} + 31{,}669\,\delta\varphi_{20} + 70{,}091\,\delta\lambda_{20} - 31{,}965\,\delta\varphi_{21} - 70{,}091\,\delta\lambda_{21} + 1{,}068$

$v_{21.15} = -z_{21} + 62{,}383\,\delta\varphi_{15} + 34{,}830\,\delta\lambda_{15} - 62{,}876\,\delta\varphi_{21} - 34{,}830\,\delta\lambda_{21} + 0{,}335$

Station North Mountain—

$v_{22.24} = -z_{22} + 42{,}454\,\delta\varphi_{22} + 101{,}424\,\delta\lambda_{22} - 42{,}730\,\delta\varphi_{24} - 101{,}424\,\delta\lambda_{24} 0{,}000$

$v_{22.23} = -z_{22} + 130{,}476\,\delta\varphi_{22} + 37{,}004\,\delta\lambda_{22} - 130{,}827\,\delta\varphi_{23} - 37{,}004\,\delta\lambda_{23} - 0{,}310$

$v_{22.19} = -z_{22} + 40{,}619\,\delta\varphi_{19} + 99{,}055\,\delta\lambda_{19} - 40{,}890\,\delta\varphi_{22} - 99{,}055\,\delta\lambda_{22} - 0{,}042$

$v_{22.20} = -z_{22} + 135{,}715\,\delta\varphi_{20} + 26{,}326\,\delta\lambda_{20} - 136{,}462\,\delta\varphi_{22} - 26{,}326\,\delta\lambda_{22} + 0{,}997$

$v_{22.21} = -z_{22} + 56{,}746\,\delta\varphi_{21} - 74{,}878\,\delta\lambda_{21} - 56{,}325\,\delta\varphi_{22} + 74{,}878\,\delta\lambda_{22} - 0{,}076$

Station Roxboro—

$v_{23.26} = -z_{23} - 20{,}559\,\delta\varphi_{23} + 142{,}628\,\delta\lambda_{23} + 20{,}661\,\delta\varphi_{26} - 142{,}628\,\delta\lambda_{26} 0{,}000$

$v_{23.27} = -z_{23} + 317{,}361\,\delta\varphi_{23} + 115{,}114\,\delta\lambda_{23} - 317{,}774\,\delta\varphi_{27} - 115{,}114\,\delta\lambda_{27} - 0{,}314$

$v_{23.28} = -z_{23} + 286{,}571\,\delta\varphi_{23} - 152{,}766\,\delta\lambda_{23} - 286{,}084\,\delta\varphi_{28} + 152{,}766\,\delta\lambda_{28} - 0{,}131$

$v_{23.22} = -z_{23} + 130{,}476\,\delta\varphi_{22} + 37{,}713\,\delta\lambda_{22} - 130{,}827\,\delta\varphi_{23} - 37{,}713\,\delta\lambda_{23} - 0{,}403$

$v_{23.24} = -z_{23} - 130{,}623\,\delta\varphi_{23} + 73{,}189\,\delta\lambda_{23} + 131{,}120\,\delta\varphi_{24} - 73{,}189\,\delta\lambda_{24} - 0{,}362$

Station Navan—

$v_{24.21} = -z_{24} + 169{,}399\,\delta\phi_{21} - 19{,}129\,\delta\lambda_{21} - 169{,}236\,\delta\varphi_{24} + 19{,}129\,\delta\lambda_{24} 0{,}000$

$v_{24.25} = -z_{24} - 28{,}155\,\delta\varphi_{24} + 204{,}548\,\delta\lambda_{24} + 28{,}253\,\delta\varphi_{25} - 204{,}548\,\delta\lambda_{25} - 0{,}340$

$v_{24.26} = -z_{24} + 222{,}653\,\delta\varphi_{24} + 43{,}134\,\delta\lambda_{24} - 222{,}916\,\delta\varphi_{26} - 43{,}134\,\delta\lambda_{26} + 0{,}125$

$v_{24.27} = -z_{24} + 125{,}319\,\delta\varphi_{24} - 30{,}471\,\delta\lambda_{24} - 125{,}007\,\delta\varphi_{27} + 30{,}471\,\delta\lambda_{27} + 0{,}547$

$v_{24.23} = -z_{24} - 130{,}623\,\delta\varphi_{23} + 73{,}900\,\delta\lambda_{23} + 131{,}120\,\delta\varphi_{24} - 73{,}900\,\delta\lambda_{24} - 0{,}248$

$v_{24.22} = -z_{24} + 42{,}454\,\delta\varphi_{22} + 102{,}135\,\delta\lambda_{22} - 42{,}730\,\delta\varphi_{24} - 102{,}135\,\delta\lambda_{24} + 0{,}175$

$v_{24.49} = -z_{24} - 246{,}368\,\delta\varphi_{24} - 32{,}563\,\delta\lambda_{24} + 246{,}185\,\delta\varphi_{49} + 32{,}563\,\delta\lambda_{49} - 0{,}602$

Station Buckingham—

$v_{25.26} = -z_{25} + 178{,}493\,\delta\Phi_{25} - 62{,}903\,\delta\lambda_{25} - 178{,}083\,\delta\varphi_{26} + 62{,}903\,\delta\lambda_{26} 0{,}000$

$v_{25.24} = -z_{25} - 28{,}155\,\delta\varphi_{24} + 205{,}262\,\delta\lambda_{24} + 28{,}253\,\delta\varphi_{25} - 205{,}262\,\delta\lambda_{25} + 0{,}840$

$v_{25.49} = -z_{25} - 120{,}234\,\delta\varphi_{25} + 97{,}351\,\delta\lambda_{25} + 119{,}727\,\delta\varphi_{49} + 97{,}351\,\delta\lambda_{49} + 0{,}866$

$v_{25.21} = -z_{25} + 152{,}962\,\delta\varphi_{21} + 49{,}201\,\delta\lambda_{21} - 153{,}348\,\delta\varphi_{25} - 49{,}201\,\delta\lambda_{25} + 0{,}496$

$v_{25.43} = -z_{25} - 167{,}043\,\delta\varphi_{25} - 50{,}027\,\delta\lambda_{25} + 166{,}674\,\delta\varphi_{43} + 50{,}027\,\delta\lambda_{43} + 0{,}480$

$v_{25.44} = -z_{25} - 184{,}903\,\delta\varphi_{25} + 36{,}121\,\delta\lambda_{25} + 185{,}171\,\delta\varphi_{44} - 36{,}121\,\delta\lambda_{44} + 0{,}73$

$v_{25.46} = -z_{25} - 93{,}133\,\delta\varphi_{25} + 66{,}389\,\delta\lambda_{25} + 93{,}650\,\delta\varphi_{46} - 66{,}389\,\delta\lambda_{46} + 0{,}529$

Station Plantagenet—

$v_{26.30} = -z_{26} + 208{,}955\,\delta\varphi_{26} + 3{,}854\,\delta\lambda_{26} - 208{,}984\,\delta\varphi_{30} - 3{,}854\,\delta\lambda_{30} 0{,}001$

$v_{26.27} = -z_{26} + 136{,}743\,\delta\varphi_{26} - 116{,}537\,\delta\lambda_{26} - 136{,}241\,\delta\varphi_{27} + 116{,}537\,\delta\lambda_{27} - 0{,}890$

$v_{26.23} = -z_{26} - 20{,}559\,\delta\varphi_{23} + 143{,}339\,\delta\lambda_{23} + 20{,}661\,\delta\varphi_{26} - 143{,}339\,\delta\lambda_{26} + 0{,}000$

$v_{26.24} = -z_{26} + 222{,}653\,\delta\varphi_{24} + 43{,}847\,\delta\lambda_{24} - 222{,}916\,\delta\varphi_{26} - 43{,}847\,\delta\varphi_{26} - 0{,}802$

$v_{26.25} = -z_{26} + 178{,}493\,\delta\varphi_{25} - 62{,}189\,\delta\lambda_{25} - 178{,}083\,\delta\varphi_{26} + 62{,}189\,\delta\lambda_{26} - 0{,}463$

Station Maxville—

$v_{27.26} = -z_{27} + 136{,}743\,\delta\varphi_{26} - 115{,}825\,\delta\lambda_{26} - 136{,}241\,\delta\varphi_{27} + 115{,}825\,\delta\lambda_{27} 0{,}000$

$v_{27.30} = -z_{27} + 104{,}905\,\delta\varphi_{27} + 152{,}312\,\delta\lambda_{27} - 105{,}306\,\delta\varphi_{30} - 152{,}312\,\delta\lambda_{20} - 0{,}253$

$v_{27.35} = -z_{27} + 133{,}182\,\delta\varphi_{27} + 39{,}882\,\delta\lambda_{27} - 133{,}551\,\delta\varphi_{35} - 39{,}882\,\delta\lambda_{35} + 0{,}363$

$v_{27.29} = -z_{27} + 420{,}234\,\delta\varphi_{27} - 50{,}993\,\delta\lambda_{27} - 420{,}066\,\delta\varphi_{29} + 50{,}993\,\delta\lambda_{29} + 0{,}543$

$v_{27.33} = -z_{27} + 114{,}927\,\delta\varphi_{27} - 41{,}916\,\delta\lambda_{27} - 114{,}515\,\delta\varphi_{33} + 41{,}916\,\delta\lambda_{33} + 1{,}260$

$v_{27.28} = -z_{27} - 29{,}838\,\delta\varphi_{27} - 237{,}339\,\delta\lambda_{27} + 29{,}748\,\delta\varphi_{28} + 237{,}339\,\delta\lambda_{28} + 1{,}285$

$v_{27.23} = -z_{27} + 317{,}361\,\delta\varphi_{23} + 115{,}824\,\delta\lambda_{23} - 317{,}774\,\delta\varphi_{27} - 115{,}824\,\delta\lambda_{27} + 1{,}117$

$v_{27.24} = -z_{27} + 125{,}319\,\delta\varphi_{24} - 29{,}760\,\delta\lambda_{24} - 125{,}007\,\delta\varphi_{27} + 29{,}760\,\delta\lambda_{27} + 1{,}129$

Station Bonville—

$v_{28.29} = -z_{28} + 194{,}703\,\delta\varphi_{28} + 136{,}705\,\delta\lambda_{28} - 195{,}210\,\delta\varphi_{29} - 136{,}705\,\delta\lambda_{29} 0{,}000$

$v_{28.33} = -z_{28} + 138{,}453\,\delta\varphi_{28} - 8{,}247\,\delta\lambda_{28} - 138{,}372\,\delta\varphi_{33} + 8{,}247\,\delta\lambda_{33} + 0{,}840$

$v_{28.23} = -z_{28} + 286{,}571\,\delta\varphi_{23} - 152{,}056\,\delta\lambda_{23} - 286{,}084\,\delta\varphi_{28} + 152{,}056\,\delta\lambda_{28} + 0{,}320$

$v_{28.27} = -z_{28} - 29{,}838\,\delta\varphi_{27} - 236{,}630\,\delta\lambda_{27} + 29{,}748\,\delta\varphi_{28} + 236{,}630\,\delta\lambda_{28} + 0{,}248$

Station Alexandria—

$v_{29.30} = -z_{29} - 28{,}604\,\delta\varphi_{29} + 167{,}807\,\delta\lambda_{29} + 28{,}724\,\delta\varphi_{30} - 167{,}807\,\delta\lambda_{30} 0{,}000$

$v_{29.35} = -z_{29} + 155{,}384\,\delta\varphi_{29} + 84{,}269\,\delta\lambda_{29} - 155{,}877\,\delta\varphi_{35} - 84{,}269\,\delta\lambda_{35} + 1{,}408$

$v_{29.31} = -z_{29} + 276{,}034\,\delta\varphi_{29} + 128{,}781\,\delta\lambda_{29} - 276{,}503\,\delta\varphi_{31} - 128{,}781\,\delta\lambda_{31} - 0{,}309$

$v_{29.33} = -z_{29} + 148{,}580\,\delta\varphi_{29} - 72{,}203\,\delta\lambda_{29} - 148{,}108\,\delta\varphi_{33} + 72{,}203\,\delta\lambda_{33} - 0{,}797$

$v_{29.28} = -z_{29} + 194{,}703\,\delta\varphi_{28} + 137{,}415\,\delta\lambda_{28} - 195{,}210\,\delta\varphi_{29} - 137{,}415\,\delta\lambda_{29} - 0{,}159$

$v_{29.27} = -z_{29} + 420{,}234\,\delta\varphi_{27} - 50{,}283\,\delta\lambda_{27} - 420{,}066\,\delta\varphi_{29} + 50{,}283\,\delta\lambda_{29} - 0{,}189$

Station Vankleek—

$v_{30.35} = -z_{30} + 210{,}750\,\delta\varphi_{30} - 33{,}933\,\delta\lambda_{30} - 210{,}530\,\delta\varphi_{35} + 33{,}933\,\delta\lambda_{35} 0{,}000$

$v_{30.31} = -z_{30} + 199{,}234\,\delta\varphi_{30} - 115{,}188\,\delta\lambda_{30} - 198{,}733\,\delta\varphi_{31} + 115{,}188\,\delta\lambda_{31} + 0{,}865$

$v_{30.29} = -z_{30} - 28{,}604\,\delta\varphi_{29} + 168{,}519\,\delta\lambda_{29} + 28{,}724\,\delta\varphi_{30} - 168{,}519\,\delta\lambda_{30} - 0{,}553$

$v_{30.27} = -z_{30} + 104{,}905\,\delta\varphi_{27} + 153{,}024\,\delta\lambda_{27} - 105{,}306\,\delta\varphi_{30} - 153{,}024\,\delta\lambda_{30} + 0{,}480$

$v_{30.26} = -z_{30} + 208{,}955\,\delta\varphi_{26} + 4{,}567\,\delta\lambda_{26} - 208{,}984\,\delta\varphi_{30} - 4{,}567\,\delta\lambda_{30} + 0{,}937$

Station Newton—

$v_{31.35} = -z_{31} + 346{,}356\,\delta\varphi_{31} + 232{,}005\,\delta\lambda_{31} - 346{,}866\,\delta\varphi_{35} - 232{,}005\,\delta\lambda_{35} 0{,}000$

$v_{31.34} = -z_{31} + 295{,}394\,\delta\varphi_{31} - 105{,}168\,\delta\lambda_{31} - 294{,}985\,\delta\varphi_{34} + 105{,}168\,\delta\lambda_{34} + 0{,}087$

$v_{31.32} = -z_{31} + 147{,}986\,\delta\varphi_{31} - 237{,}997\,\delta\lambda_{31} - 147{,}612\,\delta\varphi_{32} + 237{,}997\,\delta\lambda_{32} - 0{,}104$

$v_{31.33} = -z_{31} + 75{,}583\,\delta\varphi_{31} - 124{,}495\,\delta\lambda_{31} - 75{,}215\,\delta\varphi_{33} + 124{,}405\,\delta\lambda_{33} - 0{,}514$

$v_{31.29} = -z_{31} + 276{,}034\,\delta\varphi_{29} + 129{,}492\,\delta\lambda_{29} - 276{,}503\,\delta\varphi_{31} - 129{,}492\,\delta\lambda_{31} - 0{,}924$

$v_{31.30} = -z_{31} + 199{,}234\,\delta\varphi_{30} - 114{,}476\,\delta\lambda_{30} - 198{,}733\,\delta\varphi_{31} + 114{,}476\,\delta\lambda_{31} + 0{,}545$

OBSERVATION EQUATIONS—*Continued*

DUSABLE-HALDIMAND NET—*Continued*

STATION WEST BASE—

$v_{32.35} = -z_{32} \qquad +27{,}037\,\delta\phi_{32} + 177{,}004\,\delta\lambda_{32} - 27{,}146\,\delta\phi_{35} - 177{,}004\,\delta\lambda_{35} \qquad 0{,}000$

$v_{32.34} = -z_{32} \qquad +415{,}753\,\delta\phi_{32} + 205{,}499\,\delta\lambda_{32} - 416{,}230\,\delta\phi_{34} - 205{,}499\,\delta\lambda_{34} + 1{,}278$

$v_{32.33} = -z_{32} \qquad +116{,}317\,\delta\phi_{32} - 45{,}237\,\delta\lambda_{32} - 115{,}891\,\delta\phi_{33} + 45{,}237\,\delta\lambda_{33} + 1{,}530$

$v_{32.33} = -z_{32} \qquad +153{,}955\,\delta\phi_{32} - 259{,}830\,\delta\lambda_{32} - 153{,}594\,\delta\phi_{33} + 259{,}830\,\delta\lambda_{33} + 1{,}037$

$v_{32.31} = -z_{32} + 147{,}986\,\delta\phi_{31} - 237{,}286\,\delta\lambda_{31} - 147{,}612\,\delta\phi_{32} + 237{,}286\,\delta\lambda_{32} \qquad - 0{,}147$

STATION HUNTINGDON—

$v_{33.32} = -z_{33} + 153{,}955\,\delta\phi_{32} - 259{,}121\,\delta\lambda_{32} - 153{,}594\,\delta\phi_{33} + 259{,}121\,\delta\lambda_{33} \qquad 0{,}000$

$v_{33.35} = -z_{33} \qquad -13{,}839\,\delta\phi_{33} + 111{,}766\,\delta\lambda_{33} + 13{,}928\,\delta\phi_{35} - 111{,}766\,\delta\lambda_{35} - 0{,}229$

$v_{33.34} = -z_{33} \qquad +52{,}114\,\delta\phi_{33} + 197{,}807\,\delta\lambda_{33} - 52{,}296\,\delta\phi_{34} - 197{,}807\,\delta\lambda_{34} + 0{,}224$

$v_{33.37} = -z_{33} \qquad +68{,}125\,\delta\phi_{33} + 42{,}485\,\delta\lambda_{33} \qquad + 0{,}718$

$v_{33.38} = -z_{33} \qquad +167{,}660\,\delta\phi_{33} - 27{,}669\,\delta\lambda_{33} - 167{,}440\,\delta\phi_{38} + 27{,}669\,\delta\lambda_{38} - 0{,}593$

$v_{33.28} = -z_{33} + 138{,}453\,\delta\phi_{28} - 7{,}538\,\delta\lambda_{28} - 138{,}372\,\delta\phi_{33} + 7{,}538\,\delta\lambda_{33} \qquad + 1{,}155$

$v_{33.27} = -z_{33} + 114{,}927\,\delta\phi_{27} - 41{,}206\,\delta\lambda_{27} - 114{,}515\,\delta\phi_{33} + 41{,}206\,\delta\lambda_{33} \qquad - 1{,}043$

$v_{33.29} = -z_{33} + 148{,}580\,\delta\phi_{29} - 71{,}493\,\delta\lambda_{29} - 148{,}108\,\delta\phi_{33} + 71{,}493\,\delta\lambda_{33} \qquad - 0{,}775$

$v_{33.31} = -z_{33} + 75{,}583\,\delta\phi_{31} - 123{,}695\,\delta\lambda_{31} - 75{,}215\,\delta\phi_{33} + 123{,}695\,\delta\lambda_{33} \qquad - 0{,}020$

STATION EAST BASE—

$v_{34.35} = -z_{34} \qquad -127{,}976\,\delta\phi_{34} + 213{,}028\,\delta\lambda_{34} + 128{,}342\,\delta\phi_{35} - 213{,}028\,\delta\lambda_{35} \qquad 0{,}000$

$v_{34.37} = -z_{34} \qquad +105{,}548\,\delta\phi_{34} + 37{,}390\,\delta\lambda_{34} \qquad - 1{,}099$

$v_{34.38} = -z_{34} \qquad +105{,}309\,\delta\phi_{34} - 70{,}789\,\delta\lambda_{34} - 104{,}804\,\delta\phi_{38} + 70{,}789\,\delta\lambda_{38} + 0{,}438$

$v_{34.33} = -z_{34} + 52{,}114\,\delta\phi_{33} + 198{,}516\,\delta\lambda_{33} - 52{,}296\,\delta\phi_{34} - 198{,}516\,\delta\lambda_{34} \qquad - 0{,}154$

$v_{34.32} = -z_{34} + 415{,}753\,\delta\phi_{32} + 206{,}209\,\delta\lambda_{32} - 416{,}230\,\delta\phi_{34} - 206{,}209\,\delta\lambda_{34} \qquad + 0{,}172$

$v_{34.31} = -z_{34} + 295{,}394\,\delta\phi_{31} - 104{,}457\,\delta\lambda_{31} - 294{,}985\,\delta\phi_{34} + 104{,}457\,\delta\lambda_{34} \qquad - 0{,}329$

STATION RIGAUD—

$v_{35.30} = -z_{35} + 210{,}750\,\delta\phi_{30} - 33{,}220\,\delta\lambda_{30} - 210{,}530\,\delta\phi_{35} + 33{,}220\,\delta\lambda_{35} \qquad 0{,}000$

$v_{35.36} = -z_{35} \qquad +50{,}724\,\delta\phi_{35} + 52{,}875\,\delta\lambda_{35} - 51{,}202\,\delta\phi_{36} - 52{,}875\,\delta\lambda_{36} - 0{,}130$

$v_{35.37} = -z_{35} \qquad +113{,}384\,\delta\phi_{35} + 8{,}919\,\delta\lambda_{35} \qquad + 0{,}885$

$v_{35.38} = -z_{35} \qquad +65{,}166\,\delta\phi_{35} - 56{,}263\,\delta\lambda_{35} - 64{,}669\,\delta\phi_{38} + 56{,}263\,\delta\lambda_{38} + 0{,}098$

$v_{25.34} = -z_{35} - 127{,}976\,\delta\phi_{34} + 213{,}740\,\delta\lambda_{34} + 128{,}342\,\delta\phi_{35} - 213{,}740\,\delta\lambda_{35} \qquad + 1{,}015$

$v_{35.33} = -z_{35} - 13{,}839\,\delta\phi_{33} + 112{,}477\,\delta\lambda_{33} + 13{,}928\,\delta\phi_{35} - 112{,}477\,\delta\lambda_{35} \qquad + 0{,}853$

$v_{35.32} = -z_{35} + 27{,}037\,\delta\phi_{32} + 177{,}715\,\delta\lambda_{32} - 177{,}715\,\delta\lambda_{35} \qquad + 0{,}431$

$v_{35.31} = -z_{35} + 346{,}356\,\delta\phi_{31} + 232{,}717\,\delta\lambda_{31} - 346{,}866\,\delta\phi_{35} - 232{,}717\,\delta\lambda_{35} \qquad + 0{,}962$

$v_{35.29} = -z_{35} + 155{,}384\,\delta\phi_{29} + 84{,}981\,\delta\lambda_{29} - 155{,}877\,\delta\phi_{35} - 84{,}981\,\delta\lambda_{35} \qquad + 1{,}099$

$v_{35.27} = -z_{35} + 133{,}182\,\delta\phi_{27} + 40{,}594\,\delta\lambda_{27} - 133{,}551\,\delta\phi_{35} - 40{,}594\,\delta\lambda_{35} \qquad + 1{,}026$

STATION KILKENNY—

$v_{36.42} = -z_{36} \qquad +103{,}023\,\delta\phi_{36} + 40{,}821\,\delta\lambda_{36} - 103{,}474\,\delta\phi_{42} - 40{,}821\,\delta\lambda_{42} \qquad 0{,}000$

$v_{36.41} = -z_{36} \qquad +53{,}561\,\delta\phi_{36} - 30{,}411\,\delta\lambda_{36} - 53{,}057\,\delta\phi_{41} + 30{,}411\,\delta\lambda_{41} + 1{,}657$

$v_{36.37} = -z_{36} \qquad +36{,}027\,\delta\phi_{36} - 79{,}155\,\delta\lambda_{36} \qquad + 1{,}519$

$v_{36.35} = -z_{36} + 50{,}724\,\delta F_{35} + 53{,}591\,\delta\lambda_{35} - 51{,}202\,\delta\phi_{36} - 53{,}591\,\delta\lambda_{36} \qquad + 1{,}229$

STATION ROYAL—

$v_{37.39} =$

$v_{37.38} = \qquad +31{,}657\,\delta\phi_{38} + 76{,}163\,\delta\lambda_{38} + 0{,}188$

$v_{37.33} = +68{,}125\,\delta\phi_{33} + 43{,}195\,\delta\lambda_{33} \qquad + 1{,}193$

$v_{37.34} = +105{,}548\,\delta\phi_{34} + 38{,}102\,\delta\lambda_{34} \qquad + 0{,}032$

$v_{37.35} = +113{,}384\,\delta\phi_{35} + 9{,}632\,\delta\lambda_{35} \qquad + 0{,}511$

$v_{37.36} = +36{,}027\,\delta\phi_{35} - 78{,}439\,\delta\lambda_{36} \qquad + 0{,}731$

$v_{37.42} = \qquad -27{,}728\,\delta\phi_{42} - 49{,}226\,\delta\lambda_{42} + 0{,}833$

$v_{37.41} = \qquad -111{,}226\,\delta\phi_{41} + 10{,}049\,\delta\lambda_{41} + 0{,}302$

$v_{37.40} = \qquad -59{,}654\,\delta\phi_{40} + 32{,}912\,\delta\lambda_{40} + 0{,}965$

STATION COVEY HILL—

$v_{38.33} = -z_{38} + 167{,}660\,\delta\phi_{33} - 26{,}961\,\delta\lambda_{33} - 167{,}440\,\delta\phi_{38} + 26{,}961\,\delta\lambda_{38} \qquad 0{,}000$

$v_{38.32} = -z_{38} + 116{,}317\,\delta\phi_{32} - 44{,}529\,\delta\lambda_{32} - 115{,}891\,\delta\phi_{38} + 44{,}529\,\delta\lambda_{38} \qquad + 0{,}790$

$v_{38.34} = -z_{38} + 105{,}309\,\delta\phi_{34} - 70{,}080\,\delta\lambda_{34} - 104{,}804\,\delta\phi_{38} + 70{,}080\,\delta\lambda_{38} \qquad + 0{,}685$

$v_{38.35} = -z_{38} + 65{,}166\,\delta\phi_{35} - 55{,}553\,\delta\lambda_{35} - 64{,}669\,\delta\phi_{38} + 55{,}553\,\delta\lambda_{38} \qquad - 0{,}730$

$v_{38.37} = -z_{38} \qquad +31{,}657\,\delta\phi_{38} + 75{,}452\,\delta\lambda_{38} \qquad - 0{,}213$

$v_{38.41} = -z_{38} \qquad +61{,}084\,\delta\phi_{38} + 27{,}965\,\delta\lambda_{38} - 61{,}549\,\delta\phi_{41} - 27{,}965\,\delta\lambda_{41} - 0{,}019$

$v_{38.40} = -z_{38} \qquad +76{,}351\,\delta\phi_{38} + 1{,}696\,\delta\lambda_{38} - 76{,}389\,\delta\phi_{40} - 1{,}696\,\delta\lambda_{40} - 1{,}156$

$v_{38.39} = -z_{38} \qquad +91{,}693\,\delta\phi_{38} - 29{,}890\,\delta\lambda_{38} \qquad + 0{,}355$

STATION BELLEVUE—

$v_{39.37} =$

$v_{39.40} = \qquad -107{,}802\,\delta\phi_{40} - 86{,}743\,\delta\lambda_{40} + 0{,}272$

$v_{39.38} = +91{,}693\,\delta\phi_{38} - 29{,}184\,\delta\lambda_{38} \qquad + 0{,}394$

STATION ST. ARMAND—

$v_{40.41} = -z_{40} \qquad -31{,}173\,\delta\phi_{40} + 95{,}864\,\delta\lambda_{40} + 31{,}394\,\delta\phi_{41} - 95{,}864\,\delta\lambda_{41} \qquad 0{,}000$

$v_{40.39} = -z_{40} \qquad -107{,}802\,\delta\phi_{40} - 87{,}449\,\delta\lambda_{40} \qquad - 0{,}764$

$v_{40.38} = -z_{40} + 76.351\,\delta\phi_{38} + 2{,}404\,\delta\lambda_{38} - 76{,}389\,\delta\phi_{40} - 2{,}404\,\delta\lambda_{40} \qquad - 1{,}078$

$v_{40.37} = -z_{40} \qquad -59{,}654\,\delta\phi_{40} + 32{,}202\,\delta\lambda_{40} \qquad + 0{,}032$

STATION YAMASKA—

$v_{41.40} = -z_{41} - 31{,}173\,\delta\phi_{40} + 96{,}574\,\delta\lambda_{40} + 31{,}394\,\delta\phi_{41} - 96{,}574\,\delta\lambda_{41} \qquad 0{,}000$

$v_{41.38} = -z_{41} + 61{,}084\,\delta\phi_{38} + 28{,}675\,\delta\lambda_{38} - 61{,}549\,\delta\phi_{41} - 28{,}675\,\delta\lambda_{41} \qquad + 0{,}340$

$v_{41.37} = -z_{41} \qquad -111{,}226\,\delta\phi_{41} + 9{,}336\,\delta\lambda_{41} \qquad + 0{,}500$

$v_{41.36} = -z_{41} + 53{,}561\,\delta\phi_{36} - 29{,}695\,\delta\lambda_{36} - 53{,}057\,\delta\phi_{41} + 29{,}695\,\delta\lambda_{41} \qquad - 0{,}265$

$v_{41.42} = -z_{41} \qquad -20{,}638\,\delta\phi_{41} + 47{,}648\,\delta\lambda_{41} + 20{,}925\,\delta\phi_{42} - 47{,}648\,\delta\lambda_{42} + 0{,}452$

STATION DUSABLE—

$v_{42.41} = -z_{42} - 20{,}638\,\delta\phi_{41} + 48{,}365\,\delta\lambda_{41} + 20{,}926\,\delta\phi_{42} - 48{,}365\,\delta\lambda_{42} \qquad 0{,}000$

$v_{42.37} = -z_{42} \qquad -27{,}728\,\delta\phi_{42} - 49{,}944\,\delta\lambda_{42} \qquad + 0{,}267$

$v_{42.36} = -z_{42} + 103{,}023\,\delta\phi_{36} + 41{,}541\,\delta\lambda_{36} - 103{,}474\,\delta\phi_{42} - 41{,}541\,\delta\lambda_{42} \qquad + 0{,}992$

STATION HULL—

$v_{43.49} = -z_{43} \qquad +244{,}202\,\delta\phi_{43} - 226{,}640\,\delta\lambda_{43} - 243{,}710\,\delta\phi_{49} + 226{,}640\,\delta\lambda_{49} \qquad 0{,}000$

$v_{43.45} = -z_{43} \qquad -108{,}589\,\delta\phi_{43} + 125{,}596\,\delta\lambda_{43} + 109{,}045\,\delta\phi_{45} - 125{,}596\,\delta\lambda_{45} - 0{,}945$

$v_{43.44} = -z_{43} \qquad +4{,}957\,\delta\phi_{43} + 196{,}660\,\delta\lambda_{43} - 4{,}975\,\delta\phi_{44} - 196{,}660\,\delta\lambda_{44} - 0{,}931$

$v_{43.25} = -z_{43} - 167{,}043\,\delta\phi_{25} - 49{,}313\,\delta\lambda_{25} + 166{,}674\,\delta\phi_{43} + 49{,}313\,\delta\lambda_{43} \qquad - 1{,}010$

STATION WAKEFIELD—

$v_{44.45} = -z_{44} \qquad -379{,}847\,\delta\phi_{44} + 53{,}586\,\delta\lambda_{44} + 380{,}048\,\delta\phi_{45} - 53{,}586\,\delta\lambda_{45} \qquad 0{,}000$

$v_{44.47} = -z_{44} \qquad -113{,}189\,\delta\phi_{44} + 80{,}513\,\delta\lambda_{44} + 113{,}707\,\delta\phi_{47} - 80{,}513\,\delta\lambda_{47} + 0{,}781$

$v_{44.46} = -z_{44} \qquad -15{,}453\,\delta\phi_{44} + 176{,}239\,\delta\lambda_{44} + 15{,}516\,\delta\phi_{46} - 176{,}239\,\delta\lambda_{46} - 0{,}556$

$v_{44.25} = -z_{44} - 184{,}903\,\delta\phi_{25} + 36{,}837\,\delta\lambda_{25} + 185{,}171\,\delta\phi_{44} - 36{,}837\,\delta\lambda_{44} \qquad - 0{,}599$

$v_{44.49} = -z_{44} \qquad +43{,}932\,\delta\phi_{44} - 119{,}323\,\delta\lambda_{44} - 43{,}683\,\delta\phi_{49} + 119{,}323\,\delta\lambda_{49} - 0{,}363$

$v_{44.43} = -z_{44} + 4{,}957\,\delta\phi_{43} + 197{,}374\,\delta\lambda_{43} - 4{,}975\,\delta\phi_{44} - 197{,}374\,\delta\lambda_{44} \qquad - 0{,}305$

OBSERVATION EQUATIONS—*Concluded*

DUSABLE-HALDIMAND NET—*Concluded*

STATION MASHAM—

$v_{45.44} = -z_{45} - 379{,}847\,\delta\phi_{44} + 54{,}302\,\delta\lambda_{44} + 380{,}048\,\delta\phi_{45} - 54{,}302\,\delta\lambda_{45}$ $= 0{,}000$

$v_{45.43} = -z_{45} - 108{,}589\,\delta\phi_{43} + 126{,}311\,\delta\lambda_{43} + 109{,}045\,\delta\phi_{45} - 126{,}311\,\delta\lambda_{45}$ $= -0{,}410$

$v_{45.47} = -z_{45} - 97{,}519\,\delta\phi_{45} + 147{,}581\,\delta\lambda_{45} + 97{,}914\,\delta\phi_{47} - 147{,}581\,\delta\lambda_{47}$ $= -1{,}121$

$v_{45.46} = -z_{45} + 134{,}095\,\delta\phi_{45} + 140{,}903\,\delta\lambda_{45} - 134{,}572\,\delta\phi_{46} - 140{,}903\,\delta\lambda_{46}$ $= -0{,}290$

STATION HINCKS—

$v_{46.44} = -z_{46} - 15{,}453\,\delta\phi_{44} + 176{,}956\,\delta\lambda_{44} + 15{,}516\,\delta\phi_{46} - 176{,}956\,\delta\lambda_{46}$ $= 0{,}000$

$v_{46.45} = -z_{46} + 134{,}095\,\delta\phi_{46} + 141{,}620\,\delta\lambda_{45} - 134{,}572\,\delta\phi_{46} - 141{,}620\,\delta\lambda_{46}$ $= -0{,}221$

$v_{46.47} = -z_{46} - 242{,}469\,\delta\phi_{46} + 18{,}848\,\delta\lambda_{46} + 242{,}586\,\delta\phi_{47} - 18{,}848\,\delta\lambda_{47}$ $= -0{,}620$

$v_{46.48} = -z_{46} + 19{,}984\,\delta\phi_{46} + 187{,}203\,\delta\lambda_{46} - 20{,}061\,\delta\phi_{48} - 187{,}203\,\delta\lambda_{48}$ $= -0{,}046$

$v_{46.25} = -z_{46} - 93{,}133\,\delta\phi_{25} + 67{,}106\,\delta\lambda_{25} + 93{,}650\,\delta\phi_{46} - 67{,}106\,\delta\lambda_{46}$ $= -0{,}237$

STATION ALLEYN—

$v_{47.44} = -z_{47} - 113{,}189\,\delta\phi_{44} + 81{,}231\,\delta\lambda_{44} + 113{,}707\,\delta\phi_{47} - 81{,}231\,\delta\lambda_{47}$ $= 0{,}000$

$v_{47.45} = -z_{47} - 97{,}519\,\delta\phi_{45} + 148{,}299\,\delta\lambda_{45} + 97{,}914\,\delta\phi_{47} - 148{,}299\,\delta\lambda_{47}$ $= -1{,}285$

$v_{47.48} = -z_{47} + 148{,}047\,\delta\phi_{47} + 76{,}537\,\delta\lambda_{47} - 148{,}548\,\delta\phi_{48} - 76{,}537\,\delta\lambda_{48}$ $= -0{,}958$

$v_{47.46} = -z_{47} - 242{,}469\,\delta\phi_{46} + 19{,}567\,\delta\lambda_{46} + 242{,}586\,\delta\phi_{47} - 19{,}567\,\delta\lambda_{47}$ $= -1{,}195$

STATION BLAKE—

$v_{48.46} = -z_{48} + 19{,}984\,\delta\phi_{46} + 187{,}923\,\delta\lambda_{46} - 20{,}061\,\delta\phi_{48} - 187{,}923\,\delta\lambda_{48}$ $= 0{,}000$

$v_{48.47} = -z_{48} + 148{,}047\,\delta\phi_{47} + 77{,}257\,\delta\lambda_{47} - 148{,}548\,\delta\phi_{48} - 77{,}257\,\delta\lambda_{48}$ $= +0{,}161$

STATION OBSERVATORY—

$v_{49.43} = -z_{49} + 244{,}202\,\delta\phi_{43} - 225{,}928\,\delta\lambda_{43} - 243{,}710\,\delta\phi_{49} + 225{,}928\,\delta\lambda_{49}$ $= 0{,}000$

$v_{49.44} = -z_{49} + 43{,}932\,\delta\phi_{44} - 118{,}609\,\delta\lambda_{44} - 43{,}683\,\delta\phi_{49} + 118{,}609\,\delta\lambda_{49}$ $= +0{,}652$

$v_{49.25} = -z_{49} - 120{,}234\,\delta\phi_{25} - 96{,}638\,\delta\lambda_{25} + 119{,}727\,\delta\phi_{49} + 96{,}638\,\delta\lambda_{49}$ $= +0{,}134$

$v_{49.24} = -z_{49} - 246{,}368\,\delta\phi_{24} - 31{,}851\,\delta\lambda_{24} + 246{,}185\,\delta\phi_{49} + 31{,}851\,\delta\lambda_{49}$ $= +0{,}266$

$v_{49.21} = -z_{49} + 298{,}481\,\delta\phi_{21} - 191{,}058\,\delta\lambda_{21} - 297{,}972\,\delta\phi_{49} + 191{,}058\,\delta\lambda_{49}$ $= +1{,}108$

EFFECT ON THE TRIANGULATION DUE TO INCLUSION OF BASE AND LAPLACE CONDITIONS

Point	Correction due to inclusion of 2 Bases		Correction due to inclusion of Ottawa Laplace Point		Correction due to inclusion of Murray LaPlace Point		Total	
	$\Delta\lambda$	$\Delta\varphi$	$\Delta\lambda$	$\Delta\varphi$	$\Delta\lambda$	$\Delta\varphi$	$\Delta\lambda$	$\Delta\varphi$
	″	″	″	″	″	″	″	″
1	+·046	−·056	+·042	+·131	−·008	+·065	+·080	+·140
3	+·038	−·073	+·082	+·134	+·028	+·073	+·148	+·134
4	+·029	−·067	+·079	+·118	+·033	+·059	+·141	+·110
2	+·041	−·062	+·060	+·129	+·010	+·066	+·111	+·133
21	+·030	−·019	−·028	+·048	−·007	+·005	−·005	+·034
49	+·027	−·018	−·015	+·043	−·008	+·005	+·004	+·030
44	+·033	−·012	−·053	+·047	−·009	+·002	−·029	+·037
9	+·038	−·051	+·035	+·109	−·005	+·046	+·068	+·104
6	+·023	−·063	+·074	+·108	+·028	+·050	+·126	+·094
5	+·023	−·067	+·078	+·114	+·031	+·055	+·132	+·102
48	+·038	−·004	−·099	+·040	−·011	−·002	−·072	+·034
47	+·043	−·009	−·084	+·061	−·013	0	−·054	+·052
46	+·036	−·009	−·077	+·044	−·010	0	−·051	+·035
45	+·038	−·013	−·057	+·056	−·012	+·002	−·031	+·045
43	+·032	−·017	−·029	+·048	−·010	+·005	−·007	+·036
7	+·020	−·068	+·085	+·109	+·036	+·051	+·141	+·092
10	+·028	−·057	+·062	+·101	+·020	+·043	+·110	+·087
11	+·017	−·060	+·085	+·097	+·038	+·041	+·140	+·078
12	+·021	−·049	+·054	+·079	+·018	+·027	+·093	+·057
13	+·034	−·049	+·039	+·099	+·003	+·038	+·076	+·008
14	+·031	−·043	+·031	+·087	+·002	+·029	+·064	+·073
15	+·035	−·036	+·007	+·080	−·008	+·022	+·034	+·066
16	+·023	−·040	+·035	+·071	+·008	+·020	+·066	+·051
17	+·017	−·037	+·035	+·058	+·009	+·014	+·061	+·035
18	+·012	−·042	+·049	+·054	+·016	+·013	+·077	+·025
19	+·010	−·031	+·034	+·043	+·010	+·007	+·054	+·020
20	+·023	−·030	+·013	+·058	+·001	+·013	+·037	+·041
22	+·017	−·022	+·005	+·037	+·001	+·006	+·023	+·021
23	+·011	−·016	−·002	+·019	−·001	+·003	+·008	+·006
24	+·020	−·016	−·021	+·029	−·003	+·004	−·004	+·017
25	+·023	−·013	−·038	+·028	−·004	+·002	−·019	+·017
26	+·017	−·012	−·019	+·017	−·003	+·002	−·005	+·007
28	+·006	−·015	+·002	+·014	+ 0	+·002	+·008	+·001

EFFECT ON THE TRIANGULATION DUE TO INCLUSION OF BASE AND LAPLACE CONDITIONS—*Concluded*

Point	Correction due to inclusion of 2 Bases		Correction due to inclusion of Ottawa Laplace Point		Correction due to inclusion of Murray LaPlace Point		Total	
	$\Delta\lambda$	$\Delta\varphi$	$\Delta\lambda$	$\Delta\varphi$	$\Delta\lambda$	$\Delta\varphi$	$\Delta\lambda$	$\Delta\varphi$
	"	"	"	"	"	"	"	"
29	+·007	−·011	−·005	+·010	0	+·002	+·002	+·001
30	+·010	−·008	−·012	+·008	−·001	+·001	−·003	+·001
31	+·005	−·008	−·004	+·006	−·001	+·001	0	−·001
36	+·009	−·002	−·004	−·003	− 0	−·001	+·005	−·006
40	−·004	+·002	+·002	−·002	+ 0	0	−·002	+ 0
41	+·003	+·005	+·002	−·001	0	0	+·005	+·004
42	+·009	−·001	0	−·005	0	−·001	+·009	−·007
34	+·004	−·005	−·002	+·004	0	+·001	+·002	− 0
32	+·005	−·008	−·001	+·005	0	+·001	+·004	−·002
38	−·003	−·003	+·002	+·002	0	+ 0	−·001	−·001
33	+·001	−·009	+·002	+·005	0	+·001	+·003	−·003
27	+·012	−·012	−·006	+·014	−·001	+·002	+·005	+·004
35	+·007	−·006	−·005	+·004	− 0	+·001	+·002	−·001
8	+·027	−·063	+·069	+·113	+·024	+·055	+·120	+·105

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS

DUSABLE–HALDIMAND NET

Station occupied	Number of Direction	Object observed	Observed Direction reduced to Sea Level			Seconds of Adjusted Direction
			°	′	"	"
Methuen	1·2*	Asphodel	359	59	60·00	60·620
	9	Grimsthorpe	272	38	31·36	30·718
	8	Oak Hill	331	35	58·84	58·864
Asphodel	2·1	Methuen	359	59	60·00	59·439
	9	Grimsthorpe	61	35	21·44	21·484
	8	Oak Hill	129	22	02·34	02·488
	4	Murray	158	15	48·71	49·308
	3	Haldimand	214	17	12·31	12·088
Haldimand	3·2	Asphodel	359	59	60·00	60·305
	8	Oak Hill	48	26	39·49	39·420
	4	Murray	66	19	25·69	25·455
Murray	4·9	Grimsthorpe	359	59	60·00	59·974
	8	Oak Hill	18	39	17·20	17·537
	10	Tyendinaga	40	46	38·22	37·666
	6	East Base	57	32	33·57	33·463
	5	West Base	61	04	47·32	47·613
	11	Hallowell	85	41	45·54	45·243
	7	Ameliasburg	97	21	16·28	16·138
	3	Haldimand	251	11	27·28	27·548
	2	Asphodel	308	50	41·95	42·173
West Base	5·4	Murray	359	59	60·00	60·215
	8	Oak Hill	107	52	48·49	48·589
(Belleville)	6	East Base	174	02	16·44	16·025
	11	Hallowell	210	27	15·52	15·858
	7	Ameliasburg	238	35	48·10	47·864

*The symbol 1·2 denotes the direction from station 1 to station 2.

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS—*Continued*

DUSABLE–HALDIMAND NET—*Continued*

Station occupied	Number of Direction	Object observed	Observed Direction reduced to Sea Level			Seconds of Adjusted Direction
			°	′	″	″
East Base	6·4	Murray	359	59	60·00	60·294
	8	Oak Hill	51	29	38·92	38·776
(Belleville)	11	Hallowell	230	29	48·86	48·724
	7	Ameliasburg	296	51	42·63	42·333
	5	West Base	357	34	29·94	30·222
Ameliasburg	7·4	Murray	359	59	60·00	60·238
	5	West Base	22	19	19·53	19·649
	8	Oak Hill	45	12	02·58	02·485
	6	East Base	77	02	60·20	60·365
	10	Tyendinaga	95	26	37·81	37·707
	11	Hallowell	159	04	12·69	12·361
Oak Hill	8·4	Murray	359	59	60·00	60·124
	3	Haldimand	34	39	25·40	25·269
	2	Asphodel	81	17	39·57	39·468
	1	Methuen	103	31	36·55	36·510
	9	Grimsthorpe	154	58	55·94	55·750
	13	Kaladar	180	09	53·43	53·751
	10	Tyendinaga	215	43	49·48	48·652
	11	Hallowell	269	43	08·90	09·780
	6	East Base	270	22	53·83	53·893
	7	Ameliasburg	303	53	60·23	60·057
	5	West Base	330	18	18·23	18·301
Grimsthorpe	9·14	Olden	359	59	60·00	59·368
	13	Kaladar	23	15	36·06	36·472
	10	Tyendinaga	71	59	30·91	30·644
	8	Oak Hill	105	33	57·44	57·343
	4	Murray	111	55	45·02	45·126
	2	Asphodel	144	06	04·37	04·340
	1	Methuen	175	09	15·13	15·631
Tyendinaga	10·13	Kaladar	359	59	60·00	59·746
	12	Portland	69	06	15·27	14·650
	11	Hallowell	160	07	30·73	30·324
	7	A ıeliasburg	202	43	47·17	47·870
	4	Murray	230	42	33·64	33·794
	8	Oak Hill	244	19	02·85	03·003
	9	Grimsthorpe	329	59	46·34	46·611
Hallowell	11·4	Murray	359	59	60·00	59·897
	5	West Base	5	50	18·22	18·359
	6	East Base	22	20	38·07	37·791
	8	Oak Hill	22	40	43·59	43·746
	10	Tyendinaga	64	29	52·36	52·404
	12	Portland	117	05	51·39	51·713
	7	Ameliasburg	350	43	42·71	42·426
Portland	12·16	North Crosby	359	59	60·00	59·323
	18	Lansdowne	52	14	20·90	20·701
	11	Hallowell	190	12	12·79	12·789
	10	Tyendinaga	226	35	01·74	01·826
	13	Kaladar	270	00	26·06	26·353
	14	Olden	305	13	39·19	39·687
Kaladar	13·10	Tyendinaga	359	59	60·00	59·992
	8	Oak Hill	28	45	10·05	10·570
	9	Grimsthorpe	101	15	54·37	54·628
	15	Lavant	212	51	06·64	05·986
	14	Olden	238	25	20·98	21·057
	12	Portland	292	31	35·87	35·679

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS—*Continued*

DUSABLE-HALDIMAND NET—*Continued*

Station occupied	Number of Direction	Object observed	Observed Direction reduced to Sea Level			Seconds of Adjusted Direction
			°	′	″	″
Olden	14·12	Portland	359	59	60·00	59·731
	13	Kaladar	90	40	33·68	34·349
	9	Grimsthorpe	110	15	31·94	31·874
	15	Lavant	226	30	02·11	02·329
	16	North Crosby	305	21	01·03	00·480
Lavant	15·16	North Crosby	359	59	60·00	59·762
	14	Olden	46	53	06·05	06·574
	13	Kaladar	65	29	25·53	25·272
	21	King Mountain	257	00	44·71	44·017
	20	Elmsley	306	37	34·63	34·806
	17	Bastard	336	07	39·78	40·271
North Crosby	16·17	Bastard	359	59	60·00	59·422
	18	Lansdowne	31	17	46·14	46·215
	12	Portland	119	41	18·09	18·410
	14	Olden	190	16	01·52	02·076
	15	Lavant	244	32	00·90	00·050
	20	Elmsley	309	52	09·90	10·381
Bastard	17·16	North Crosby	359	59	60·00	60·183
	15	Lavant	40	39	43·80	44·065
	20	Elmsley	87	11	14·26	13·943
	19	Elizabethtown	178	19	26·76	26·432
	18	Lansdowne	250	31	21·36	21·554
Lansdowne	18·19	Elizabethtown	359	59	60·00	59·925
	12	Portland	215	47	52·87	53·124
	16	North Crosby	255	10	02·51	02·786
	17	Bastard	294	23	39·43	38·963
Elizabethtown	19·17	Bastard	359	59	60·00	59·518
	20	Elmsley	44	53	23·11	23·625
	22	North Mountain	107	04	14·94	14·671
	18	Lansdowne	317	48	13·72	13·956
Elmsley	20·21	King Mountain	359	59	60·00	60·219
	22	North Mountain	56	54	22·98	22·215
	19	Elizabethtown	116	03	32·15	32·440
	17	Bastard	160	01	58·38	58·226
	16	North Crosby	202	42	57·18	57·559
	15	Lavant	264	00	26·32	26·347
King Mountain	21·25	Buckingham	359	59	60·00	59·606
	26	Plantagenet	23	02	24·23	24·872
	24	Navan	33	41	40·00	39·970
	23	Roxboro	48	21	22·99	22·839
	49	Ottawa	66	52	37·93	37·570
	22	North Mountain	86	30	50·09	49·629
	20	Elmsley	132	31	46·37	47·041
	15	Lavant	166	55	29·34	29·430
North Mountain	22·24	Navan	359	59	60·00	59·906
	23	Roxboro	51	23	51·27	50·470
	19	Elizabethtown	180	00	12·53	12·509
	20	Elmsley	238	40	14·49	15·560
	21	King Mountain	315	45	02·22	02·065

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS—*Continued*

DUSABLE—HALDIMAND NET—*Continued*

Station occupied	Number of Direction	Object observed	Observed Direction reduced to Sea Level			Seconds of Adjusted Direction
			°	′	″	″
Roxboro	23·26	Plantagenet	359	59	60·00	60·291
	27	Maxville	68	28	34·93	34·010
	28	Bonville	132	41	11·39	11·108
	22	North Mountain	253	58	34·71	35·244
	24	Navan	314	27	56·09	56·468
Navan	24·21	King Mountain	359	59	60·00	60·254
	25	Buckingham	75	01	47·41	47·492
	26	Plantagenet	154	55	10·63	10·375
	27	Maxville	189	11	03·31	03·114
	23	Roxboro	208	57	12·38	11·816
	22	North Mountain	277	04	03·37	03·820
	49	Ottawa	340	08	28·56	28·768
Buckingham	25·26	Plantagenet	359	59	60·00	58·610
	24	Navan	58	03	23·15	23·013
	49	Ottawa	104	42	38·24	38·835
	21	King Mountain	129	19	57·74	57·461
	43	Hull	130	46	20·89	21·073
	44	Wakefield	169	26	36·50	37·250
	46	Hincks	199	21	13·74	14·022
Plantagenet	26·30	Vankleek	359	59	60·00	59·751
	27	Maxville	52	04	47·26	46·451
	23	Roxboro	85	57	48·88	49·273
	24	Navan	166	23	46·19	46·160
	25	Buckingham	208	26	59·67	60·368
Maxville	27·26	Plantagenet	359	59	60·00	59·798
	30	Vankleek	65	20	58·46	57·968
	35	Rigaud	106	10	18·15	17·527
	29	Alexandria	139	08	59·33	58·720
	33	Huntingdon	156	27	26·85	27·062
	28	Bonville	224	36	49·86	49·997
	23	Roxboro	282	21	34·70	35·028
	24	Navan	328	34	49·10	50·354
Bonville	28·29	Alexandria	359	59	60·00	59·811
	33	Huntingdon	49	18	33·51	33·097
	23	Roxboro	261	56	16·77	17·514
	27	Maxville	319	58	56·25	56·109
Alexandria	29·30	Vankleek	359	59	60·00	60·087
	35	Rigaud	59	04	29·01	29·976
	31	Newton	63	14	08·19	07·939
	33	Huntingdon	131	06	25·09	24·206
	28	Bonville	232	04	16·07	15·983
	27	Maxville	286	35	21·55	21·717
Vankleek	30·35	Rigaud	359	59	60·00	59·253
	31	Newton	26	37	08·18	08·451
	29	Alexandria	70	30	06·17	05·122
	27	Maxville	103	17	26·28	26·961
	26	Plantagenet	165	51	43·06	43·904
Newton	31·35	Rigaud	359	59	60·00	59·250
	34	East Base	70	15	62·21	61·925
	32	West Base	109	53	42·56	43·269
	33	Huntingdon	110	19	25·31	25·033
	29	Alexandria	190	10	23·75	23·352
	30	Vankleek	263	03	18·98	19·980

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS—*Continued*

DUSABLE—HALDIMAND NET—*Continued*

Station occupied	Number of Direction	Object observed	Observed Direction reduced to Sea Level			Seconds of Adjusted Direction
			°	′	″	″
West Base	32·35	Rigaud	359	59	60·00	59·476
	34	East Base	48	47	61·17	61·177
	38	Covey Hill	112	18	27·84	28·176
	33	Huntingdon	151	05	11·54	11·619
	31	Newton	330	11	42·33	42·426
Huntingdon	33·32	West Base	359	59	60·00	59·737
	35	Rigaud	17	44	22·71	22·464
	34	East Base	33	15	17·34	17·449
	37	Royal	70	53	18·51	18·995
	38	Covey Hill	125	30	39·82	38·624
	28	Bonville	297	31	46·80	48·315
	27	Maxville	320	02	51·07	50·592
	29	Alexandria	327	15	25·56	25·293
	31	Newton	359	32	11·96	12·305
East Base	34·35	Rigaud	359	59	60·00	60·139
	37	Royal	85	49	35·12	34·362
	38	Covey Hill	156	13	22·56	23·158
	33	Huntingdon	213	28	56·45	56·603
	32	West Base	257	56	28·93	28·950
	31	Newton	319	42	29·55	29·401
Rigaud	35·30	Vankleek	359	59	60·00	59·823
	36	Kilkenny	110	46	30·15	29·354
	37	Royal	160	13	13·76	13·786
	38	Covey Hill	217	33	23·79	22·955
	34	East Base	234	07	20·14	20·263
	33	Huntingdon	252	05	22·12	22·349
	32	West Base	263	15	47·98	47·976
	31	Newton	303	33	47·73	47·462
	29	Alexandria	309	34	33·07	33·716
	27	Maxville	324	06	44·12	45·170
Kilkenny	36·42	Dusable	359	59	60·00	59·118
	41	Yamaska	68	31	32·57	32·869
	37	Royal	102	16	46·70	46·783
	35	Rigaud	154	04	03·22	03·701
Royal	37·39	Bellevue	359	59	60·00	60·000
	38	Covey Hill	43	49	28·17	28·251
	33	Huntingdon	75	53	30·38	31·498
	34	East Base	90	36	10·01	10·118
	35	Rigaud	110	52	31·63	32·047
	36	Kilkenny	189	38	38·03	38·155
	42	Dusable	228	19	52·61	53·195
	41	Yamaska	304	03	06·28	06·188
	40	St. Armand	334	32	19·89	20·790
Covey Hill	38·33	Huntingdon	359	59	60·00	59·814
	32	West Base	15	42	38·00	38·708
	34	East Base	30	29	06·45	07·287
	35	Rigaud	37	41	48·47	47·829
	37	Royal	93	18	42·33	42·267
	41	Yamaska	133	23	14·57	14·333
	40	St. Armand	164	20	39·73	38·757
	39	Bellevue	191	03	09·18	09·731
Bellevue	39·37	Royal	359	59	60·00	60·000
	40	St. Armand	68	01	54·06	54·505
	38	Covey Hill	321	33	46·33	46·662

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS—*Concluded*

DUSABLE—HALDIMAND NET—*Concluded*

Station occupied	Number of Direction	Object observed	Observed Direction reduced to Sea Level			Seconds of Adjusted Direction
			°	′	″	″
St. Armand	40·41	Yamaska	359	59	60·00	60·035
	39	Bellevue	234	16	16·18	16·171
	38	Covey Hill	281	05	43·94	43·369
	37	Royal	320	46	50·23	50·778
Yamaska	41·40	St. Armand	359	59	60·00	59·721
	38	Covey Hill	70	08	27·94	28·074
	37	Royal	110	17	41·64	42·013
	36	Kilkenny	142	08	07·66	07·133
	42	Dusable	176	15	45·12	45·424
Dusable	42·41	Yamaska	359	59	60·00	59·403
	37	Royal	38	18	54·83	54·667
	36	Kilkenny	77	20	58·35	59·108
Hull	43·49	Ottawa	359	59	60·00	60·680
	45	Masham	186	05	00·24	00·014
	44	Wakefield	218	14	55·04	55·138
	25	Buckingham	284	07	17·56	17·009
Wakefield	44·45	Masham	359	59	60·00	59·427
	47	Alleyn	34	09	21·22	22·011
	46	Hincks	74	57	58·89	58·455
	25	Buckingham	184	01	34·50	34·249
	49	Ottawa	243	55	12·35	12·513
	43	Hull	259	28	57·74	58·044
Masham	45·44	Wakefield	359	59	60·00	59·755
	43	Hull	47	19	03·96	04·178
	47	Alleyn	233	53	28·71	28·283
	46	Hincks	292	09	37·77	38·221
Hincks	46·44	Wakefield	359	59	60·00	60·090
	45	Masham	37	11	40·38	40·542
	47	Alleyn	100	06	45·41	45·201
	48	Blake	187	45	31·12	31·249
	25	Buckingham	318	58	10·83	10·661
Alleyn	47·44	Wakefield	359	59	60·00	60·596
	45	Masham	19	44	07·79	07·459
	48	Blake	277	45	34·59	34·498
	46	Hincks	320	55	20·68	20·512
Blake	48·46	Hincks	359	59	60·00	59·946
	47	Alleyn	49	11	29·26	29·313
Ottawa	49·43	Hull	359	59	60·00	59·826
	44	Wakefield	22	41	08·57	09·312
	25	Buckingham	78	03	35·51	35·275
	24	Navan	116	31	02·55	02·129
	21	King Mountain	349	33	30·36	30·449

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Murray	4	57 39 14·63	14·67	− 0·04
Haldimand	3	66 19 25·15	25·69	− 0·54
Asphodel	2	56 01 22·78	23·60	− 0·82
		02·56	03·96	
		ϵ =02·54	Δ'r closure =	− 1·40
East Base	6	2 25 30·07	30·06	+ 0·01
West Base	5	174 02 15·81	16·44	− 0·63
Murray	4	3 32 14·15	13·75	+ 0·40
		0·03	0·25	
		ϵ = 0·03	Δ'r closure =	− 0·22
Ameliasburg	7	22 19 19·41	19·53	− 0·12
Murray	4	36 16 28·53	28·96	− 0·43
West Best	5	121 24 12·36	11·90	+ 0·46
		0·30	0·39	
		ϵ = 0·28	Δ'r closure =	− 0·09
Ameliasburg	7	54 43 40·72	40·67	+ 0·05
West Base	5	64 33 31·83	31·66	+ 0·17
East Base	6	60 42 47·89	47·31	+ 0·58
		0·44	59·64	
		ϵ = 0·45	Δ'r closure =	+ 0·80
Ameliasburg	7	77 03 00·12	00·20	− 0·08
Murray	4	39 48 42·68	42·71	− 0·03
East Base	6	63 08 17·96	17·37	+ 0·59
		0·76	0·28	
		ϵ = 0·76	Δ'r closure =	+ 0·48
Oak Hill	8	33 31 06·17	06·40	− 0·23
East Base	6	114 37 56·44	56·29	+ 0·15
Ameliasburg	7	31 50 57·88	57·62	+ 0·26
		0·49	0·31	
		ϵ = 0·49	Δ'r closure =	+ 0·18
Oak Hill	8	59 55 24·41	24·40	+ 0·01
East Base	6	53 55 08·56	08·98	− 0·42
West Base	5	66 09 27·44	27·95	− 0·51
		0·41	01·33	
		ϵ = 0·41	Δ'r closure =	− 0·92
Oak Hill	8	89 37 06·23	06·17	+ 0·06
East Base	6	51 29 38·49	38·92	− 0·43
Murray	4	38 53 15·92	16·37	− 0·45
		0·64	01·46	
		ϵ = 0·64	Δ'r closure =	− 0·82
Oak Hill	8	26 24 18·24	18·00	+ 0·24
Ameliasburg	7	22 52 42·84	43·05	− 0·21
West Base	5	130 42 59·27	59·61	− 0·34
		0·35	0·66	
		ϵ = 0·35	Δ'r closure =	− 0·31
Oak Hill	8	56 06 00·06	59·77	+ 0·29
Ameliasburg	7	45 12 02·25	02·58	− 0·33
Murray	4	78 41 58·60	59·08	− 0·48
		0·91	01·42	
		ϵ = 0·90	Δ'r closure =	− 0·52

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″		
Oak Hill	8	29 41 41·82	41·77	+ 0·05
West Base	5	107 52 48·37	48·49	− 0·12
Murray	4	42 25 30·07	30·12	− 0·05
		0·26	0·38	
		ϵ = 0·26	Δ'r closure =	− 0·12
Oak Hill	8	34 39 25·15	25·40	− 0·25
Murray	4	127 27 49·99	49·92	+ 0·07
Haldimand	3	17 52 46·04	46·20	− 0·16
		01·18	01·52	
		ϵ =01·17	Δ'r closure =	− 0·34
Oak Hill	8	81 17 39·35	39·57	− 0·22
Murray	4	69 48 35·37	35·25	+ 0·12
Asphodel	2	28 53 46·82	46·37	+ 0·45
		01·54	01·19	
		ϵ =01·53	Δ'r closure =	+ 0·35
Oak Hill	8	46 38 14·20	14·17	+ 0·03
Haldimand	3	48 26 39·11	39·49	− 0·38
Asphodel	2	84 55 09·60	09·97	− 0·37
		02·91	03·63	
		ϵ =02·91	Δ'r closure =	− 0·72
Oak Hill	8	22 13 57·04	56·98	+ 0·06
Asphodel	2	129 22 03·05	02·34	+ 0·71
Methuen	1	28 24 01·78	01·16	+ 0·62
		01·87	0·48	
		ϵ =01·90	Δ'r closure =	+ 1·39
Grimsthorpe	9	6 21 47·79	47·57	+ 0·22
Oak Hill	8	154 58 55·63	55·94	− 0·31
Murray	4	18 39 17·57	17·20	+ 0·37
		0·99	0·71	
		ϵ = 0·96	Δ'r closure =	+ 0·28
Grimsthorpe	9	38 32 07·00	06·93	+ 0·07
Oak Hill	8	73 41 16·28	16·37	− 0·09
Asphodel	2	67 46 41·01	40·90	+ 0·11
		4·29	4·20	
		ϵ = 4·28	Δ'r closure =	+ 0·09
Grimsthorpe	9	69 35 18·29	17·69	+ 0·60
Oak Hill	8	51 27 19·24	19·39	− 0·15
Methuen	1	58 57 28·15	27·48	+ 0·67
		05·68	04·56	
		ϵ =05·67	Δ'r closure =	+ 1·12
Grimsthorpe	9	32 10 19·21	19·35	− 0·14
Murray	4	51 09 17·80	18·05	− 0·25
Asphodel	2	96 40 27·83	27·27	+ 0·56
		04·84	04·67	
		ϵ =04·84	Δ'r closure =	+ 0·17
Grimsthorpe	9	31 03 11·29	10·76	+ 0·53
Asphodel	2	61 35 22·04	21·44	+ 0·60
Methuen	1	87 21 29·90	28·64	+ 1·26
		03·23	0·84	
		ϵ =03·24	Δ'r closure =	+ 2·39

TABLE OF TRIANGLES—DUSABLE-HALDIMAND NET—*Continued*

Station	Station number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Tyendinaga	10	27 58 45·92	46·47	− 0·55
Ameliasburg	7	95 26 37·47	37·81	− 0·34
Murray	4	56 34 38·47	38·06	+ 0·41
		01·86	02·34	
		ε = 01·86	Δ'r closure =	− 0·48
Tyendinaga	10	41 35 15·13	15·68	− 0·55
Ameliasburg	7	50 14 35·22	35·23	− 0·01
Oak Hill	8	88 10 11·41	10·75	+ 0·66
		01·76	01·66	
		ε = 01·76	Δ'r closure =	+ 0·10
Tyendinaga	10	99 17 12·82	12·70	+ 0·12
Murray	4	40 46 37·70	38·22	− 0·52
Grimsthorpe	9	39 56 14·49	14·11	+ 0·38
		05·01	05·03	
		ε = 04·99	Δ'r closure =	− 0·02
Tyendinaga	10	13 36 29·21	29·21	0·00
Murray	4	22 07 20·13	21·02	− 0·89
Oak Hill	8	144 16 11·47	10·52	+ 0·95
		0·81	0·75	
		ε = 0·81	Δ'r closure =	+ 0·06
Tyendinaga	10	85 40 43·61	43·49	+ 0·12
Oak Hill	8	60 44 52·90	53·54	− 0·64
Grimsthorpe	9	33 34 26·70	26·53	+ 0·17
		03·21	03·56	
		ε = 03·21	Δ'r closure =	− 0·35
Hallowell	11	9 16 17·47	17·29	+ 0·18
Ameliasburg	7	159 04 12·12	12·69	− 0·57
Murray	4	11 39 30·90	30·74	+ 0·16
		0·49	0·72	
		ε = 0·49	Δ'r closure =	− 0·23
Hallowell	11	15 06 35·93	35·51	+ 0·42
Ameliasburg	7	136 44 52·71	53·16	− 0·45
West Base	5	28 08 32·00	32·58	− 0·58
		0·64	01·25	
		ε = 0·64	Δ'r closure =	− 0·61
Hallowell	11	31 57 01·32	00·88	+ 0·44
Ameliasburg	7	113 52 09·87	10·11	− 0·23
Oak Hill	8	34 10 50·28	51·33	− 1·05
		1·47	02·32	
		ε = 1·47	Δ'r closure =	− 0·84
Hallowell	11	73 46 09·97	09·65	+ 0·32
Ameliasburg	7	63 37 34·65	34·88	− 0·23
Tyendinaga	10	42 36 17·55	16·44	+ 1·11
		02·17	0·97	
		ε = 02·18	Δ'r closure =	+ 1·20
Hallowell	11	5 50 18·46	18·22	+ 0·24
Murray	4	24 36 57·63	58·22	− 0·59
West Base	5	149 32 44·36	44·48	− 0·12
		0·45	0·92	
		ε = 0·45	Δ'r closure =	− 0·47

TABLE OF TRIANGLES—DUSABLE-HALDIMAND NET—*Continued*

Station	Station number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Hallowell	11	22 20 37·89	38·07	− 0·18
Murray	4	28 09 11·78	11·97	− 0·19
East Base	6	129 30 11·57	11·14	+ 0·43
		01·24	01·18	
		ε = 01·24	Δ'r closure =	+ 0·06
Hallowell	11	22 40 43·85	43·59	+ 0·26
Murray	4	67 02 27·70	28·34	− 0·64
Oak Hill	8	90 16 50·34	51·10	− 0·76
		01·89	03·03	
		ε = 01·90	Δ'r closure =	− 1·14
Hallowell	11	64 29 52·50	52·36	+ 0·14
Murray	4	44 55 07·57	07·32	+ 0·25
Tyendinaga	10	70 35 03·47	02·91	+ 0·56
		03·54	02·59	
		ε = 03·55	Δ'r closure =	+ 0·95
Hallowell	11	16 50 25·39	25·37	+ 0·02
West Base	5	102 34 27·27	27·03	+ 0·24
Oak Hill	8	60 35 08·52	09·33	− 0·81
		01·18	01·73	
		ε = 01·18	Δ'r closure =	− 0·55
Hallowell	11	16 30 19·43	19·85	− 0·42
West Base	5	36 24 59·83	59·08	+ 0·75
East Base	6	127 04 41·50	41·08	+ 0·42
		0·76	0·01	
		ε = 0·76	Δ'r closure =	+ 0·75
Hallowell	11	16 50 25·39	25·37	+ 0·02
East Base	5	102 34 27·27	27·03	+ 0·24
Oak Hill	8	60 35 08·52	09·33	− 0·81
		01·18	01·73	
		ε = 01·18	Δ'r closure =	− 0·55
Hallowell	11	41 49 08·65	08·77	− 0·12
Oak Hill	8	53 59 21·13	19·42	+ 1·71
Tyendinaga	10	84 11 32·68	32·12	+ 0·56
		02·46	0·31	
		ε = 02·47	Δ'r closure =	+ 2·15
Portland	12	36 22 49·04	48·95	+ 0·09
Hallowell	11	52 35 59·31	59·03	+ 0·28
Tyendinaga	10	91 01 15·67	15·46	+ 0·21
		04·02	03·44	
		ε = 04·02	Δ'r closure =	+ 0·58
Kaladar	13	72 30 44·06	44·32	− 0·26
Oak Hill	8	25 10 58·00	57·49	+ 0·51
Grimsthorpe	9	82 18 20·87	21·38	− 0·51
		02·93	03·19	
		ε = 02·93	Δ'r closure =	− 0·26
Kaladar	13	101 15 54·64	54·37	+ 0·27
Tyendinaga	10	30 00 13·14	13·66	− 0·52
Grimsthorpe	9	48 43 54·17	54·85	− 0·68
		01·95	02·88	
		ε = 01·94	Δ'r closure =	− 0 93

TABLE OF TRIANGLES—DUSABLE-HALDIMAND NET—*Continued*

Station	Station Number	Angle				
		Adjusted			Observed	Correction
		°	′	″	″	″
Kaladar	13	28	45	10·58	10·05	+ 0·53
Tyendenaga	10	115	40	56·75	57·15	− 0·40
Oak Hill	8	35	33	54·90	56·05	− 1·15
				02·23	03·25	
				ε =02·22	Δ'r closure =	− 1·02
Kaladar	13	67	28	24·31	24·13	+ 0·18
Portland	12	43	25	24·52	24·32	+ 0·20
Tyendinaga	10	69	06	14·90	15·27	− 0·37
				03·73	03·72	
				ε =03·74	Δ'r closure =	+ 0·01
Olden	14	90	40	34·62	33·68	+ 0·94
Portland	12	35	13	13·34	13·13	+ 0·21
Kaladar	13	54	06	14·62	14·89	− 0·27
				02·58	01·70	
				ε =02·57	Δ'r closure =	+ 0·88
Olden	14	19	34	57·52	58·26	− 0·74
Kaladar	13	137	09	26·43	26·61	− 0·18
Grimsthorpe	9	23	15	37·10	36·06	+ 1·04
				01·05	00·93	
				ε =01·06	Δ'r closure =	+ 0·12
Lavant	15	18	36	18·17	19·48	− 0·78
Olden	14	135	49	27·98	28·43	− 0·45
Kaladar	13	25	34	15·07	14·34	+ 0·73
				01·75	02·25	
				ε =01·75	Δ'r closure =	− 0·50
North Crosby	16	70	34	43·67	43·43	+ 0·24
Portland	12	54	46	19·63	20·81	− 1·18
Olden	14	54	38	59·25	58·97	+ 0·28
				02·55	03·21	
				ε =02·56	Δ'r closure =	− 0·66
North Crosby	16	54	15	57·97	59·38	− 1·41
Olden	14	78	50	58·15	58·92	− 0·77
Lavant	15	46	53	06·81	06·05	+ 0·76
				02·93	04·35	
				ε =02·94	Δ'r closure =	− 1·42
Bastard	17	40	39	43·89	43·80	+ 0·09
North Crosby	16	115	27	59·37	59·10	+ 0·27
Lavant	15	23	52	19·49	20·22	− 0·73
				02·75	03·12	
				ε =02·74	Δ'r closure =	− 0·37
Lansdowne	18	39	22	09·67	09·64	+ 0·03
Portland	12	52	14	21·38	20·90	+ 0·48
North Crosby	16	88	23	32·19	31·95	+ 0·24
				03·24	02·49	
				ε =03·24	Δ'r closure =	+ 0·75
Lansdowne	18	39	13	36·17	36·92	− 0·75
North Crosby	16	31	17	46·80	46·14	+ 0·66
Bastard	17	109	28	38·63	38·64	− 0·01
				01·60	01·70	
				ε =01·60	Δ'r closure =	− 0·10

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Elizabethtown	19	42 11 45·56	46·28	− 0·72
Lansdowne	18	65 36 20·97	20·57	+ 0·40
Bastard	17	72 11 55·12	54·60	+ 0·52
		01·65	01·45	
		ε = 01·65	Δ'r closure =	+ 0·20
Elmsley	20	43 58 25·79	26·23	− 0·44
Elizabethtown	19	44 53 24·11	23·11	+ 1·00
Bastard	17	91 08 12·49	12·50	− 0·01
		02·39	01·84	
		ε = 02·38	Δ'r closure =	+ 0·55
Elmsley	20	42 40 59·33	58·80	+ 0·53
Bastard	17	87 11 13·76	14·26	− 0·50
North Crosby	16	50 07 49·04	50·10	− 1·06
		02·13	03·16	
		ε = 02·13	Δ'r closure =	− 1·03
Elmsley	20	103 58 28·12	27·94	+ 0·18
Bastard	17	46 31 29·87	30·46	− 0·59
Lavant	15	29 30 05·46	05·15	+ 0·31
		03·45	03·55	
		ε = 03·46	Δ'r closure =	− 0·10
Elmsley	20	61 17 28·79	29·14	− 0·35
North Crosby	16	65 20 10·33	09·00	+ 1·33
Lavant	15	53 22 24·95	25·37	− 0·42
		04·07	03·51	
		ε = 04·08	Δ'r closure =	+ 0·56
King Mountain	21	34 23 42·39	42·97	− 0·58
Elmsley	20	95 59 33·87	33·68	+ 0·19
Lavant	15	49 36 50·79	49·92	+ 0·87
		07·05	06·57	
		ε = 07·05	Δ'r closure =	+ 0·48
North Mountain	22	58 40 03·05	01·96	+ 1·09
Elizabethtown	19	62 10 51·04	51·83	− 0·79
Elmsley	20	59 09 10·22	09·17	+ 1·05
		04·31	02·96	
		ε = 04·32	Δ'r closure =	+ 1·35
North Mountain	22	77 04 46·51	47·73	− 1·22
Elmsley	20	56 54 22·00	22·98	− 0·98
King Mountain	21	46 00 57·41	56·28	+ 1·13
		05·92	06·99	
		ε = 05·91	Δ'r closure =	− 1·07
Navan	24	68 06 52·00	50·99	+ 1·01
Roxboro	23	60 29 21·23	21·38	− 0·15
North Mountain	22	51 23 50·58	51·27	− 0·69
		03·81	03·64	
		ε = 03·79	Δ'r closure =	+ 0·17
Navan	24	82 55 56·43	56·63	− 0·20
North Mountain	22	44 14 57·84	57·78	+ 0·06
King Mountain	21	52 49 09·66	10·09	− 0·43
		03·93	04·50	
		ε = 03·93	Δ'r closure =	− 0·57

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station number	Angle		
		Adjusted	Observed	Corrected
		° ′ ″	″	″
Navan	24	19 51 31·48	31·44	+ 0·04
Ottawa	49	126 57 31·68	32·19	− 0·51
King Mountain	21	33 10 57·60	57·93	− 0·33
		00·76	01·56	
		ϵ =00·77	Δ′r closure =	− 0·80
Buckingham	25	46 39 15·83	15·09	+ 0·74
Navan	24	94 53 18·72	18·85	− 0·13
Ottawa	49	38 27 26·85	27·04	− 0·19
		01·40	00·98	
		ϵ =01·40	Δ′r closure =	+ 0·42
Buckingham	25	71 16 34·45	34·59	− 0·14
Navan	24	75 01 47·24	47·41	− 0·17
King Mountain	21	33 41 40·36	40·00	+ 0·36
		02·05	02·00	
		ϵ =02·05	Δ′r closure =	+ 0·05
Buckingham	25	24 37 18·62	19·50	− 0·88
Ottawa	49	88 30 04·83	05·15	− 0·32
King Mountain	21	66 52 37·96	37·93	+ 0·03
		01·41	02·58	
		ϵ =01·42	Δ′r closure =	− 0·07
Hull	43	75 52 43·67	42·44	+ 1·23
Buckingham	25	26 03 42·23	42·65	− 0·42
Ottawa	49	78 03 35·45	35·51	− 0·06
		01·35	00·60	
		ϵ =01·36	Δ′r closure =	+ 0·75
Wakefield	44	59 53 38·26	37·85	+ 0·41
Buckingham	25	64 43 58·41	58·26	+ 0·15
Ottawa	49	55 22 25·97	26·94	− 0·97
		02·64	03·05	
		ϵ =02·64	Δ′r closure =	− 0·41
Wakefield	44	75 27 23·79	23·24	+ 0·55
Buckingham	25	38 40 16·18	15·61	+ 0·57
Hull	43	65 52 21·87	22·52	− 0·65
		01·84	01·37	
		ϵ =01·84	Δ′r closure =	+ 0·47
Wakefield	44	15 33 45·54	45·39	+ 0·14
Ottawa	49	22 41 09·48	08·57	+ 0·91
Hull	43	141 45 05·54	04·96	+ 0·58
		0·56	58·92	
		ϵ = 0·56	Δ′r closure =	+ 1·63
Masham	45	47 19 04·42	03·96	+ 0·46
Wakefield	44	100 31 01·39	02·26	− 0·87
Hull	43	32 09 55·13	54·80	+ 0·33
		0·94	01·02	
		ϵ = 0·93	Δ′r closure =	− 0·08
Hincks	46	41 01 49·43	49·17	+ 0·26
Buckingham	25	29 54 36·77	37·24	− 0·47
Wakefield	44	109 03 35·79	35·61	+ 0·18
		01·99	02·02	
		ϵ =01·99	Δ′r closure =	− 0·03

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Hincks	46	37 11 40·45	40·38	+ 0·07
Wakefield	44	74 57 59·03	58·89	+ 0·14
Masham	45	67 50 21·54	22·23	− 0·69
		01·02	01·50	
		ϵ =01·01	Δ'r closure =	− 0·48
Alleyn	47	39 04 40·09	39·32	+ 0·77
Hincks	46	100 06 45·11	45·41	− 0·30
Wakefield	44	40 48 36·45	37·67	− 1·22
		01·65	02·40	
		ϵ =01·64	Δ'r closure =	− 0·75
Alleyn	47	58 48 46·95	47·11	− 0·16
Hincks	46	62 55 04·66	05·03	− 0·37
Masham	45	58 16 09·94	09·06	+ 0·88
		01·55	01·20	
		ϵ =01·54	Δ'r closure =	+ 0·35
Alleyn	47	19 44 06·86	07·79	− 0·93
Wakefield	44	34 09 22·58	21·22	+ 1·36
Masham	45	126 06 31·48	31·29	+ 0·19
		00·92	00·30	
		ϵ =00·92	Δ'r closure =	+ 0·62
Blake	48	49 11 29·36	29·26	+ 0·10
Hincks	46	87 38 46·05	45·71	+ 0·34
Alleyn	47	43 09 46·01	46·09	− 0·08
		1·42	01·06	
		ϵ = 1·43	Δ'r closure =	+ 0·36
Plantagenet	26	80 25 56·89	57·31	− 0·42
Roxboro	23	45 32 03·82	03·91	− 0·09
Navan	24	54 02 01·44	01·75	− 0·31
		02·15	02·97	
		ϵ =02·15	Δ'r closure =	− 0·82
Plantagenet	26	42 03 14·21	13·48	+ 0·73
Navan	24	79 53 22·89	23·22	− 0·33
Buckingham	25	58 03 24·40	23·15	+ 1·25
		01·50	59·85	
		ϵ =01·49	Δ'r closure =	+ 1·65
Maxville	27	46 13 15·32	14·40	+ 0·92
Roxboro	23	114 00 37·54	38·84	− 1·30
Navan	24	19 46 08·71	09·07	− 0·36
		01·57	02·31	
		ϵ =01·57	Δ'r closure =	− 0·74
Maxville	27	77 38 24·77	25·30	− 0·53
Roxboro	23	68 28 33·72	34·93	− 1·21
Plantagenet	26	33 53 02·82	01·62	+ 1·20
		01·31	01·85	
		ϵ =01·31	Δ'r closure =	− 0·54
Maxville	27	31. 25 09·45	10·90	− 1·45
Navan	24	34 15 52·73	52·68	+ 0·05
Plantagenet	26	114 18 59·71	58·93	+ 0·78
		01·89	02·51	
		ϵ =01·89	Δ'r closure =	− 0·62

TABLE OF TRIANGLES—DUSABLE-HALDIMAND NET—*Continued.*

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Bonville	28	58 02 38·60	39·48	− 0·88
Roxboro	23	64 12 37·10	36·46	+ 0·64
Maxville	27	57 44 45·03	44·84	+ 0·19
		00·73	00·78	
		ε =00·72	Δ'r closure =	− 0·05
Alexandria	29	54 31 05·74	05·48	+ 0·26
Bonville	28	40 01 03·70	03·75	− 0·05
Maxville	27	85 27 51·28	50·53	+ 0·75
		00·72	59·76	
		ε =00·72	Δ'r closure =	+ 0·96
Vankleek	30	32 47 21·84	20·11	+ 1·73
Alexandria	29	73 24 38·37	38·45	− 0·08
Maxville	27	73 48 00·75	00·87	− 0·12
		00·96	59·43	
		ε =00·96	Δ'r closure =	+ 1·53
Vankleek	30	62 34 16·94	16·78	+ 0·16
Maxville	27	65 20 58·17	58·46	− 0·29
Plantagenet	26	52 04 46·70	47·26	− 0·56
		01·81	02·50	
		ε =01·81	Δ'r closure =	− 0·69
Newton	31	72 52 56·63	55·23	+ 1·40
Alexandria	29	63 14 07·85	08·19	− 0·34
Vankleek	30	43 52 56·67	57·99	− 1·32
		01·15	01·41	
		ε =01·15	Δ'r closure =	− 0·26
Huntingdon	33	22 31 02·27	04·27	− 2·00
Bonville	28	89 19 36·99	37·26	− 0·27
Maxville	27	68 09 22·94	23·01	− 0·07
		02·20	04·54	
		ε =02·20	Δ'r closure =	− 2·34
Huntingdon	33	29 43 36·97	38·76	− 1·79
Bonville	28	49 18 33·29	33·51	− 0·22
Alexandria	29	100 57 51·77	50·98	+ 0·79
		02·03	03·25	
		ε =02·04	Δ'r closure =	− 1·22
Huntingdon	33	7 12 34·70	34·49	+ 0·21
Maxville	27	17 18 28·34	27·52	+ 0·82
Alexandria	29	155 28 57·51	56·46	+ 1·05
		00·55	58·47	
		ε =00·56	Δ'r closure =	+ 2·08
Huntingdon	33	32 16 47·02	46·40	+ 0·62
Alexandria	29	67 52 16·27	16·90	− 0·63
Newton	31	79 50 58·32	58·44	− 0·12
		01·61	01·74	
		ε =01·60	Δ'r closure =	− 0·13
Huntingdon	33	00 27 47·43	48·04	− 0·61
Newton	31	00 25 41·76	42·75	− 0·99
West Base	32	179 06 30·81	30·79	+ 0·02
		00·00	01·58	
		ε =00·00	Δ'r closure =	− 1·58

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station Number	Angle			
		Adjusted	Observed	Correction
		° ′ ″	″	″
East Base	34	44 27 32·35	32·48	− 0·13
Huntingdon	33	33 15 17·71	17·34	+ 0·37
West Base	32	102 17 10·44	10·37	+ 0·07
		00·50	00·19	
		ε =00·50	Δ'r closure =	+ 0·31
East Base	34	106 13 32·80	33·10	− 0·30
Huntingdon	33	33 43 05·14	05·38	− 0·24
Newton	31	40 03 23·10	23·10	0·00
		01·04	01·58	
		ε =01·03	Δ'r closure =	− 0·54
East Base	34	61 46 00·45	00·62	− 0·17
West Base	32	78 36 18·75	18·84	− 0·09
Newton	31	39 37 41·34	40·35	+ 0·99
		00·54	59·81	
		ε =00·55	Δ'r closure =	+ 0·73
Rigaud	35	17 58 02·09	01·98	+ 0·11
East Base	34	146 31 03·54	03·55	− 0·01
Huntingdon	33	15 30 54·99	54·63	+ 0·36
		00·62	00·16	
		ε =00·62	Δ'r closure =	+ 0·46
Rigaud	35	29 08 27·72	27·84	− 0·12
East Base	34	102 03 31·19	31·07	+ 0·12
West Base	32	48 48 01·70	01·17	+ 0·53
		00·61	00·08	
		ε =00·60	Δ'r closure =	+ 0·53
Rigaud	35	69 26 27·20	27·59	− 0·39
East Base	34	40 17 30·74	30·45	+ 0·29
Newton	31	70 16 02·68	02·21	+ 0·47
		00·62	00·25	
		ε =00·61	Δ'r closure =	+ 0·37
Rigaud	35	11 10 25·63	25·86	− 0·23
Huntingdon	33	17 44 22 72	22·71	+ 0·01
West Base	32	151 05 12·14	11·54	+ 0·60
		00·49	00·11	
		ε =00·50	Δ'r closure =	+ 0·38
Rigaud	35	51 28 25·11	25·61	− 0·50
Huntingdon	33	18 12 10·15	10·75	− 0·60
Newton	31	110 19 25·78	25·31	+ 0·47
		01·04	01·67	
		ε =01·05	Δ'r closure =	− 0·63
Rigaud	35	57 29 11·37	10·95	+ 0·42
Huntingdon	33	50 28 57·17	57·15	+ 0·02
Alexandria	29	72 01 54 23	56·08	− 1·85
		02·77	04·18	
		ε =02·77	Δ'r closure =	− 1·41
Rigaud	35	72 01 22·82	22·00	+ 0·82
Huntingdon	33	57 41 31·87	31·64	+ 0·23
Maxville	27	50 17 09·53	08·70	+ 0·83
		04·22	02·34	
		ε =04·23	Δ'r closure =	+ 1·88

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station Number	Angle				
		Adjusted			Observed	Correction
		°	′	″	″	″
Rigaud	35	40	17	59·48	59·75	− 0·27
West Base	32	29	48	17·05	17·67	− 0·62
Newton	31	109	53	44·02	42·56	+ 1·46
				00·55	59·98	
				ϵ =00·56	Δ'r closure =	+ 0·57
Rigaud	35	6	00	46·26	45·34	+ 0·92
Newton	31	169	49	35·90	36·25	− 0·35
Alexandria	29	4	09	37·96	39·18	− 1·22
				00·12	00·77	
				ϵ =00·11	Δ'r closure =	− 0·65
Rigaud	35	56	26	12·36	12·27	+ 0·09
Newton	31	96	56	39·27	41·02	− 1·75
Vankleek	30	26	37	09·20	08·18	+ 1·02
				00·83	01·47	
				ϵ =00·83	Δ'r closure =	− 0·64
Rigaud	35	50	25	26·10	26·93	− 0·83
Alexandria	29	59	04	29·89	29·01	+ 0·88
Vankleek	30	70	30	05·87	06·17	− 0·30
				01·86	02·11	
				ϵ =01·86	Δ'r closure =	− 0·25
Rigaud	35	14	32	11·45	11·05	+ 0·40
Alexandria	29	132	29	08·26	07·46	+ 0·80
Maxville	27	32	58	41·19	41·18	+ 0·01
				00·90	59·69	
				ϵ =00·90	Δ'r closure =	+ 1·21
Rigaud	35	35	53	14·65	15·88	− 1·23
Maxville	27	40	49	19·56	19·69	− 0·13
Vankleek	30	103	17	27·71	26·28	+ 1·43
				01·92	01·85	
				ϵ =01·92	Δ'r closure =	+ 0·07
Royal	37	14	42	38·62	39·63	− 1·01
Huntingdon	33	37	38	01·55	01·17	+ 0·38
East Base	34	127	39	22·24	21·33	+ 0·91
				02·41	02·13	
				ϵ =02·41	Δ'r closure =	+ 0·28
Royal	37	34	59	00·55	01·25	− 0·70
Huntingdon	33	53	08	56·54	55·80	+ 0·74
Rigaud	35	91	52	08·56	08·36	+ 0·20
				05·65	05·41	
				ϵ =05·64	Δ'r closure =	+ 0·24
Royal	37	20	16	21·93	21·62	+ 0·31
East Base	34	85	49	34·22	35·12	− 0·90
Rigaud	35	73	54	06·47	06·38	+ 0·09
				02·62	03·12	
				ϵ =02·63	Δ'r closure =	− 0·50
Royal	37	78	46	06·11	06·40	− 0·29
Rigaud	35	49	26	44·44	43·61	+ 0·83
Kilkenny	36	51	47	16·92	16·52	+ 0·40
				07·47	06·53	
				ϵ =07·48	Δ'r closure =	+ 0·94

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Continued*

Station	Station Number	Angle				
		Adjusted			Observed	Correction
		°	′	″	″	″
Covey Hill	38	15	42	38·90	38·00	+ 0·90
Huntingdon	33	125	30	38·88	39·82	− 0·94
West Base	32	38	46	43·44	43·70	− 0·26
				01·22	01·52	
				ε =01·22	Δ'r closure =	− 0·30
Covey Hill	38	30	29	07·48	06·45	+ 1·03
Huntingdon	33	92	15	21·17	22·48	− 1·31
East Base	34	57	15	33·44	33·89	− 0·45
				02·09	02,82	
				ε =02·10	Δ'r closure =	− 0·73
Covey Hill	38	37	41	48·02	48·47	− 0·45
Huntingdon	33	107	46	16·16	17·11	− 0·95
Rigaud	35	34	31	59·39	58·33	+ 1·06
				03·57	03·91	
				ε =03·57	Δ'r closure =	− 0·34
Covey Hill	38	93	18	42·46	42·33	+ 0·13
Huntingdon	33	54	37	19·62	21·31	− 1·69
Royal	37	32	04	03·25	02·21	+ 1·04
				05·33	05·85	
				ε =05·33	Δ'r closure =	− 0·52
Covey Hill	38	14	46	28·58	28·45	+ 0·13
West Base	32	63	30	27·00	26·67	+ 0·33
East Base	34	101	43	05·79	06·37	− 0·58
				01·37	01·49	
				ε =01·37	Δ'r closure =	− 0·12
Covey Hill	38	21	59	09·12	10·47	− 1·35
West Base	32	112	18	28·70	27·84	+ 0·86
Rigaud	35	45	42	25·02	24·19	+ 0·83
				02·84	02·50	
				ε =02·84	Δ'r closure =	+ 0·34
Covey Hill	38	7	12	40·54	42·02	− 1·48
East Base	34	156	13	23·02	22·56	+ 0·46
Rigaud	35	16	33	57·30	56·35	+ 0·95
				00·86	00·93	
				ε =00·87	Δ'r closure =	− 0·07
Covey Hill	38	62	49	34·98	35·88	− 0·90
East Base	34	70	23	48·80	47·44	+ 1·36
Royal	37	46	46	41·87	41·84	+ 0·03
				05·65	05·16	
				ε =05·64	Δ'r closure =	+ 0·49
Covey Hill	38	55	36	54·44	53·86	+ 0·58
Rigaud	35	57	20	09·17	10·03	− 0·86
Royal	37	67	03	03·80	03·46	+ 0·34
				07·41	07·35	
				ε =07·40	Δ'r closure =	+ 0·06
Bellevue	39	38	26	13·34	13·67	− 0·33
Covey Hill	38	97	44	27·46	26·85	+ 0·61
Royal	37	43	49	28·25	28·17	+ 0·08
				09·05	08·69	
				ε =09·05	Δ'r closure =	+ 0·36

TABLE OF TRIANGLES—DUSABLE–HALDIMAND NET—*Concluded*

Station	Station Number	Angle				
		Adjusted			Observed	Correction
		°	′	″	″	″
St. Armand	40	46	49	27·20	27·76	− 0·56
Bellevue	39	106	28	07·85	07·73	+ 0·12
Covey Hill	38	26	42	30·97	29·45	+ 1·52
				06·02	04·94	
				ϵ =06·02	Δ'r closure =	+ 1·08
St. Armand	40	86	30	34·61	34·05	+ 0·56
Bellevue	39	68	01	54·51	54·06	+ 0·45
Royal	37	25	27	39·21	40·11	− 0·90
				08·33	08·22	
				ϵ =08·32	Δ'r closure =	+ 0·11
St. Armand	40	39	41	07·41	06·29	+ 1·12
Covey Hill	38	71	01	56·49	57·40	− 0·91
Royal	37	69	17	07·46	08·28	− 0·82
				11·36	11·97	
				ϵ =11·36	Δ'r closure =	− 0·61
Yamaska	41	70	08	28·35	27·94	+ 0·41
St. Armand	40	78	54	16·67	16·06	+ 0·61
Covey Hill	38	30	57	24·43	25·16	− 0·73
				09·45	09·16	
				ϵ =09·44	Δ'r closure =	+ 0·29
Yamaska	41	110	17	42·29	41·64	+ 0·65
St. Armand	40	39	13	09·26	09·77	− 0·51
Royal	37	39	29	14·60	13·61	+ 0·99
				06·15	05·02	
				ϵ =06·15	Δ'r closure =	+ 1·13
Yamaska	41	40	09	13·94	13·70	+ 0·24
Covey Hill	38	40	04	32·06	32·24	− 0·18
Royal	37	99	46	22·06	21·89	+ 0·17
				08·06	07·83	
				ϵ =08·07	Δ'r closure =	+ 0·23
Yamaska	41	31	50	25·12	26·02	− 0·90
Royal	37	114	24	28·03	28·25	− 0·22
Kilkenny	36	33	45	13·91	14·13	− 0·22
				07·06	08·40	
				ϵ =07·07	Δ'r closure =	− 1·34
Dusable	42	38	18	55·27	54·83	+ 0·44
Yamaska	41	65	58	03·41	03·48	− 0·07
Royal	37	75	43	12·99	13·67	− 0·68
				11·67	11·98	
				ϵ =11·67	Δ'r closure =	− 0·31
Dusable	42	77	20	59·71	58·35	+ 1·36
Yamaska	41	34	07	38·29	37·46	+ 0·83
Kilkenny	36	68	31	33·75	32·57	+ 1·18
				11·75	08·38	
				ϵ =11·75	Δ'r closure =	+ 3·37

Direction	Elmsley	Ashton	Carp	Lavant
co-log sin 1″	5·3144251	5·3144251	5·3144251	5·3144251
log eccentric distance	1·8080718	1·8080718	1·8080718	1·8080718
co-log distance	5·2117357	5·4002839	5·6988242	5·0958937
log sin direction	9·9995802*n*	9·9999313*n*	9·9808789*n*	9·9291034*n*
	2·3338128*n*	2·5227121*n*	2·8022000*n*	2·1474940*n*
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
correction to direction	— 3 35·68	— 5 33·21	— 10 34·16	— 2 20·44
observed direction	267 28 51·76	268 58 51·72	286 52 39·40	301 51 19·48
reduced direction	267 25 16·08	268 53 18·51	286 42 05·24	301 48 59·04

Reduction to Sea Level

In accordance with the statement on page 8, the correction to reduce each observed direction to sea level has been omitted. The maximum correction for the territory covered by this triangulation, in which the greatest elevation is about 1,200 feet above sea level and the longest line is about 30 miles, could not exceed 0·″05, and in general would be less than 0·″02. The probable error of an observation of weight unity is seldom less than 0·″4, so that the corrections omitted are insignificant in comparison.

Preliminary Co-ordinates

In order that a simple expression might be obtained for the observation equation it was assumed that the corrections to the preliminary co-ordinates would be small, and therefore that their squares and higher powers could be neglected. It is immaterial which method of computing the preliminary co-ordinates is used so long as the most probable corrections to these values resulting from the adjustment are not so large that they would fail to satisfy the above imposed condition.

In the following table are given the preliminary co-ordinates of all points whose positions are to be determined, as well as the direct and reverse azimuths and the distances of the lines joining them. It is essential that the azimuths and distances should correspond exactly with the data furnished by the co-ordinates, as the final azimuths and distances are determined by adding differentials obtained by substituting the most probable corrections to the preliminary positions in the differential expressions for azimuth and distance.

PRELIMINARY GEOGRAPHICAL CO-ORDINATES OF OTTAWA-GROVETON NET FOR OBSERVATION EQUATIONS

North American Datum

Station	ϕ_1	λ_1	$\alpha_{1.2}$	log d	$\alpha_{2.1}$	ϕ_2	λ_2	Station
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	° ′ ″	° ′ ″	
Pakenham	45 19 40·223	76 21 48·499	65 11 03·30	4·6338771	245 32 24·45	45 29 21·427	75 51 49·475	King Mountain
			85 38 43·44	4·4335575	265 53 27·46	45 20 45·088	76 01 05·596	Carp
			126 51 10·18	4·5129077	307 05 17·50	45 09 05·587	76 01 55·202	Ashton
Carp	45 20 45·088	76 01 05·596	37 07 38·33	4·3011954	217 14 14·42	45 29 21·427	75 51 49·475	King Mountain
			77 18 13·66	4·3867159	257 31 11·22	45 23 37·076	75 42 52·985	Ottawa
			94 34 00·19	4·4571576	274 49 32·93	45 19 29·100	75 39 14·149	Bowesville
Bowesville	45 19 29·100	75 39 14·149	58 38 24·09	4·3745570	238 49 26·52	45 26 07·389	75 23 43·488	Navan
			133 07 56·07	4·4552075	313 19 12·63	45 08 56·291	75 23 21·283	Ormond
			163 39 46·38	4·4702895	343 44 15·81	45 04 10·924	75 32 54·421	North Mountain
Ashton	45 09 05·587	76 01 55·202	19 18 21·28	4·5997274	199 25 31·98	45 29 21·427	75 51 49·475	King Mountain
			56 54 25·57	4·5487682	237 10 31·97	45 19 29·100	75 39 14·149	Bowesville
			90 31 08·52	4·3984084	270 44 40·69	45 08 56·647	75 42 49·620	North Gower
			149 14 36·01	4·2280879	329 19 15·68	45 01 14·726	75 55 20·286	Montague
North Gower	45 08 56·647	75 42 49·620	13 30 48·06	4·3028103	193 33 21·05	45 19 29·100	75 39 14·149	Bowesville
			89 54 34·67	4·4069338	270 08 22·96	45 08 56·291	75 23 21·283	Ormond
			124 04 27·24	4·1964353	304 11 28·91	45 04 10·924	75 32 54·421	North Mountain
			158 26 15·95	4·4866691	338 32 19·26	44 53 32·421	75 34 16·011	Groveton
Montague	45 01 14·726	75 55 20·286	31 53 18·70	4·6002127	212 04 43·92	45 19 29·100	75 39 14·149	Bowesville
			48 56 57·92	4·3373659	229 05 49·51	45 08 56·647	75 42 49·620	North Gower
			79 24 18·52	4·4764352	259 40 10·94	45 04 10·924	75 32 54·421	North Mountain
			117 07 24·88	4·4937445	297 22 18·18	44 53 32·421	75 34 16·011	Groveton
			154 55 49·76	4·6084063	335 05 00·62	44 41 22·973	75 42 19·279	Elizabethtown
Ormond	45 08 56·291	75 23 21·283	74 24 31·43	4·4836916	254 40 25·29	45 13 19·268	75 00 56·661	Roxboro
			116 37 50·81	4·4642836	296 51 53·14	45 01 51·652	75 03 31·905	Osnabruck
			158 10 19·26	4·3559083	338 14 51·74	44 57 33·674	75 16 56·301	Dundela
Groveton	44 53 32·421	75 34 16·011	5 10 27·22	4·2964726	185 11 24·89	45 04 10·924	75 32 54·421	North Mountain
			26 37 17·47	4·5040583	206 45 00·61	45 08 56·291	75 23 21·283	Ormond
			71 48 37·30	4·3799762	252 00 51·54	44 57 33·674	75 16 56·301	Dundela
Dundela	44 57 33·674	75 16 56·301	338 14 51·74	4·3559083	158 10 19·26	45 08 56·291	75 23 21·283	Ormond
Osnabruck	45 01 51·652	75 03 31·905	9 03 56·20	4·3323656	189 05 46·22	45 13 19·268	75 00 56·661	Roxboro
			59 01 28·71	4·3124069	239 10 59·03	45 07 33·156	74 50 06·446	Bonville
Lavant	45 02 44·551	76 40 10·560	76 35 01·77	4·7122093	257 02 07·64	45 09 05·587	76 01 55·202	Ashton
Elizabethtown	44 41 22·973	75 42 19·279	25 12 36·04	4·3961493	205 18 16·52	44 53 32·421	75 34 16·011	Groveton
Elmsley	44 57 48·047	76 06 13·347	65 53 59·15	4·1949001	246 01 40·87	45 01 14·726	75 55 20·286	Montague
King Mountain	45 29 21·427	75 51 49·475	137 59 34·22	4·3905907	318 08 32·10	45 19 29·100	75 39 14·149	Bowesville
North Mountain	45 04 10·924	75 32 54·421	54 49 57·01	4·1851526	234 56 43·05	45 08 56·291	75 23 21·283	Ormond
Navan	45 26 07·389	75 23 43·488	179 07 36·92	4·5029049	359 07 52·70	45 08 56·291	75 23 21·283	Ormond

Differential Formulæ

For the sake of convenience the differential formulæ are here repeated. We have for the change in azimuth,—

$$\delta\alpha_{1\cdot2} = \frac{R_1 \sin \alpha_{1\cdot2}}{m}\,\delta\phi_1 + \frac{R_2 \sin \alpha_{2\cdot1}}{m}\,\delta\phi_2 + \frac{N_2 \cos \phi_2 \cos \alpha_{2\cdot1}}{m}\,(\delta\lambda_2 - \delta\lambda_1)$$

$$\delta\alpha_{2\cdot1} = \frac{R_2 \sin \alpha_{2\cdot1}}{m}\,\delta\phi_2 + \frac{R_1 \sin \alpha_{1\cdot2}}{m}\,\delta\phi_1 + \frac{N_1 \cos \phi_1 \cos \alpha_{1\cdot2}}{m}\,(\delta\lambda_2 - \delta\lambda_1)$$

where m $= S + 2$, where 2 = 2nd and higher powers of $\frac{S}{R}$ and for the change in distance,—

$$-\delta s = \sin 1'' \,(R_1 \cos \alpha_{1\cdot2}\,\delta\phi_1 + R_2 \cos \alpha_{2\cdot1}\,\delta\phi_2 + N_2 \cos \phi_2 \sin \alpha_{2\cdot1}\,(\delta\lambda_1 - \delta\lambda_2))$$

The observation equation is:

$v_{1\cdot2} = -z + \delta\alpha_{1\cdot2}$ + computed azimuth − observed azimuth.

For the purpose of tabulation it will be more convenient to condense the above formulæ by introducing single letters to represent the more complex coefficients. We may then write:—

$$\delta\alpha_{1\cdot2} = A\,\delta\,\phi_1 + B\,\delta\,\phi_2 + C\,(\delta\lambda_2 - \delta\lambda_1)$$
$$\delta\alpha_{2\cdot1} = B\,\delta\,\phi_2 + A\,\delta\,\phi_1 + D\,(\delta\lambda_1 - \delta\lambda_2)$$
$$-\delta s = E\,\delta\,\phi_1 + F\,\delta\,\phi_2 + G\,(\delta\lambda_1 - \delta\lambda_2)$$
$$v_{1\cdot2} = -z + A\,\delta\,\phi_1 + B\,\delta\,\phi_2 + C\,(\delta\lambda_2 - \delta\lambda_1) + \alpha_c - \alpha_o$$

These formulæ will now be applied to the observations made at the station Ashton. Following is the computation for the coefficients *A*, *B*, *C*, etc., of the line Ashton to Bowesville, the necessary data being obtained from the table of preliminary co-ordinates. In a similar manner the values given in the table of coefficients for the station Ashton may be found. The calculation of a coefficient is omitted whenever the differential is equal to zero. In this example we have the differentials for the stations Lavant and King Mountain equal to zero, the positions of these stations having been fixed by the adjustment of the Dusable–Haldimand net.

EVALUATION OF COEFFICIENTS FOR LINE ASHTON-BOWESVILLE

$\log R_1$	= 6·8039691	$\log R_1$	= 6·8039691	$\log N_1$	= 6·8054386		
$\log \sin \alpha_{1\cdot2}$	= 9·9231333	$\log \cos \alpha_{1\cdot2}$	= 9·7371912	$\log \cos \alpha_{1\cdot2}$	= 9·7371912		
co-log *s*	= 5·4512318	log sin 1″	= 4·6855749	$\log \cos \phi_1$	= 9·8483332		
log *A*	= 2·1783342	log *E*	= 1·2267352	co-log *s*	= 5·4512318		
				log *D*	= 1·8421948		
A	= +150·777	*E*	= + 16·855	*D*	= + 69·534		
$\log R_2$	= 6·8039825	$\log R_2$	= 6·8039825	$\log N_2$	= 6·8054431	$\log N_2$	= 6·8054431
$\log \sin \alpha_{2\cdot1}$	= 9·9244526*n*	$\log \cos \alpha_{2\cdot1}$	= 9·7340529*n*	$\log \cos \alpha_{2\cdot1}$	= 9·7340529*n*	$\log \sin \alpha_{2\cdot1}$	= 9·9244526*n*
colog *s*	= 5·4512318	log sin 1″	= 4·6855749	$\log \cos \phi_2$	= 9·8470094	$\log \cos \phi_2$	= 9·8470094
log *B*	= 2·1796669*n*	log *F*	= 1·2236103*n*	co-log *s*	= 5·4512318	log sin 1″	= 4·6855749
				log *C*	= 1·8377372*n*	log *G*	= 1·2624809*n*
B	= −151·240	*F*	= −16·734	*C*	= −68·824	*G*	= −18·301

TABLE OF COEFFICIENTS

Station—Ashton

To station	Number of line	Values of						
		A	*B*	*C*	*D*	*E*	F	*G*
King Mountain	4·21	+ 52·913	.....	− 105·172	+ 106·883	+ 29·134	.....	− 7·222
Bowesville	4· 3	+ 150·777	− 151·240	− 68·824	+ 69·534	+ 16·855	− 16·734	− 18·301
North Gower	4· 5	+ 254·415	− 254·404	+ 2·340	− 1·631	− 0·222	+ 0·401	− 21·844
Montague	4· 6	+ 192·591	− 192·143	+ 229·717	− 229·009	− 26·529	+ 26·549	− 11·171
Lavant	4·15	− 120·378	.....	+ 20·318	− 19·610	− 6·926	.....	+ 21·238
Pakenham	4· 1	− 155·921	+ 156·409	− 82·699	+ 83·409	+ 18·616	− 18·516	+ 17·425

Calculation of Absolute Terms

The calculation for the absolute terms of the observation equations for the station Ashton follows. The computed azimuth is obtained from the table of preliminary co-ordinates. The observed azimuth at any station not having a fixed line emanating therefrom may be taken equal to the computed azimuth for any one line, but generally it will be more convenient to equate these for the line used as initial for the directions. Then the observed azimuth for any other line can be obtained by simply adding the observed direction to the assumed observed azimuth of the initial. In the case where observed directions are connected with a line fixed in azimuth the observed azimuth of this line must be taken equal to the fixed value.

		°	′	″
Observed azimuth Ashton to King Mountain	$= \alpha_o =$	+19	18	21·277
Computed azimuth Ashton to King Mountain	$= \alpha_c =$	19	18	21·277
	$\alpha_c - \alpha_o =$			0·000

		°	′	″
Observed azimuth Ashton to King Mountain	=	+19	18	21·277
Observed angle King Mountain-Ashton-Bowesville	=	37	36	06·080
∴ Observed azimuth Ashton to Bowesville	$= \alpha_o =$	+56	54	27·357
Computed azimuth Ashton to Bowesville	$= \alpha_c =$	56	54	25·566
	$\therefore \alpha_c - \alpha_o =$			−1·791

		°	′	″
Observed azimuth Ashton to King Mountain	=	+19	18	21·277
Observed angle King Mouutain-Ashton-North Gower	=	71	12	52·630
∴ Observed azimuth Ashton to North Gower	$= \alpha_o =$	+90	31	13·907
Computed azimuth Ashton to North Gower	$= \alpha_c =$	90	31	08·517
	$\therefore \alpha_c - \alpha_o =$			−5·390

		°	′	″
Observed azimuth Ashton to King Mountain	=	+19	18	21·277
Observed angle King Mountain-Ashton-Montague	=	129	57	03·170
∴ Observed azimuth Ashton to Montague	$= \alpha_o =$	+149	15	24·447
Computed azimuth Ashton to Montague	$= \alpha_c =$	149	14	36·010
	$\therefore \alpha_c - \alpha_o =$			−48·437

		°	′	″
Observed azimuth Ashton to King Mountain	=	+19	18	21·277
Observed angle King Mountain-Ashton-Pakenham	=	287	46	47·700
∴ Observed azimuth Ashton to Pakenham	$= \alpha_o =$	+307	05	08·977
Computed azimuth Ashton to Pakenham	$= \alpha_c =$	307	05	17·502
	$\therefore \alpha_c - \alpha_o =$			+8·525

Observation Equations

At all adjusted stations of the Ottawa–Groveton net directions are considered which have been observed in a series with the directions entering into the Dusable–Haldimand net. By the adjustment of the latter net these directions become fixed and a value of the orientation factor z is obtained from the consideration of these only. From the previously adjusted stations observation equations with z omitted are written for the new lines only, the observations over the old lines being disregarded, the result being the same as if the angle method of adjustment had been used.

In this method of adjustment Jordan suggests that observations at fixed points be assigned only half weight. In this adjustment all directions whether at adjusted or unadjusted stations are treated with unit weight. This has

been done because of the difficulty of determining even approximately correct weights.

Collecting the coefficients A, B, C, from the computation of coefficients for the line Ashton to Bowesville we have for the change in azimuth the differential expression

$$\delta\alpha_{4\cdot3} = -151\cdot240\ \delta\phi_3 - 68\cdot824\ \phi\lambda_3 + 150\cdot777\ \delta\phi_4 + 68\cdot824\ \delta\lambda_4$$

The observation equation is

$$v_{4\cdot3} = -z_4 - 151\cdot240\ \delta\phi_3 - 68\cdot824\ \delta\lambda_3 + 150\cdot777\ \delta\phi_4 + 68\cdot824\ \delta\lambda_4 - 1\cdot791$$

In a similar manner all of the observation equations for the station Ashton may be formed. Herewith are given the five observation equations for the observations made at Ashton.

STATION ASHTON..

$v_{4\cdot21} = -z_4$				$+52\cdot913\ \delta\phi_4$	$+106\cdot172\ \delta\lambda_4$					$0\cdot000$
$v_{4\cdot3} = -z_4$	$-151\cdot240\ \delta\phi_3$	$-68\cdot824\ \phi\lambda_3$		$+150\cdot777\ \delta\phi_4$	$+68\cdot824\ \delta\lambda_4$					$-1\cdot791$
$v_{4\cdot5} = -z_4$				$+254\cdot415\ \delta\phi_4$	$-2,340\ \delta\lambda_4$	$-254\cdot404\ \delta\phi_5$	$+2\cdot340\ \delta\lambda_5$			$-5\cdot390$
$v_{4\cdot6} = -z_4$				$+192\cdot591\ \delta\phi_4$	$-229\cdot717\ \delta\lambda_4$	$-192\cdot148\ \delta\phi_5$	$+229\cdot717\ \delta\lambda_5$			$-48\cdot437$
$v_{4\cdot1} = -z_4$	$+156\cdot409\ \delta\phi_1$	$-82\cdot699\ \delta\lambda_1$		$-155\cdot921\ \delta\phi_4$	$+82\cdot699\ \delta\lambda_4$					$+8\cdot525$

These observation equations in conjunction with those formed for the other stations serve for the formation of the normal equations, and a solution of these will give the desired corrections to the following co-ordinates.

ELIMINATION OF Z

As these observation equations contain z's which are of no particular interest in themselves, the work may be done in any of the following methods:—

(I) The value of z for each station may be found by forming the normal equations for that station and solving for z, and this value substituted in the observation equations gives a new set of observation equations from which we form our normal equations for the system.

(II) The normal equations for each station are formed and the z eliminated and these reduced normal equations of each station are added together term for term giving the normal equations for the system.

Suppose our n observation equations for a station are:—

$$v_1 = z + a_1 x + b_1 y + c_1 u + l_1$$
$$v_2 = z + a_2 x + b_2 y + c_2 u + l_2$$
$$v_n = z + a_n x + b_n y + c_n u + l_n$$

our partial normal equations are:—

$$nz + [a]\ x + [b]\ y + [c]\ u + [l] = 0 \qquad (1)$$
$$+ [aa]\ x + [ab]\ y + [ac]\ u + [al] = 0 \qquad (2)$$
$$+ [bb]\ y + [bc]\ u + [bl] = 0 \qquad (3)$$
$$+ [cc]\ u + [cl] = 0 \qquad (4)$$

From (1) $$z = -\frac{a}{n}x - \frac{b}{n}y - \frac{c}{n}u - \frac{l}{n}$$

Substituting this value of z in (2), (3) and (4) we get:—

$$\left([aa] - \frac{a}{n}[a]\right)x + \left([ab] - \frac{a}{n}[b]\right)y + \left([ac] - \frac{a}{n}[c]\right)u + [al] - \frac{a}{n}[l] = 0$$
$$+ \left([bb] - \frac{b}{n}[b]\right)y + \left([bc] - \frac{b}{n}[c]\right)u + [bl] - \frac{b}{n}[l] = 0$$
$$+ \left([cc] - \frac{c}{n}[c]\right)u + [cl] - \frac{c}{n}[l] = 0$$

These added term for term to partial normal equations formed similarly for other stations give the normal equations for the system.

(III) The work is made easier by the following mechanical rule: The observation equations at a point are written down with z omitted giving ea c unit weight and a fictitious equation equal to the sum of the others is add e

with a negative weight equal to $-\frac{1}{n}$. To reduce this to unit weight it must be multiplied by

$$\sqrt{-\frac{1}{n}} = \sqrt{-1}\ \sqrt{\frac{1}{n}} = i\ \sqrt{\frac{1}{n}} \text{ where } i = \sqrt{-1}$$

		Wt (p)	$\sqrt{p}$	
v_1	$= a_1 x + b_1 y + c_1 u + l_1$	1	1	(1)
v_2	$= a_2 x + b_2 y + c_2 u + l_2$	1	1	(2)
v_n	$= a_n x + b_n y + c_n u + l_n$	1	1	(n)

The consequent fictitious equation is:—

$$v_f = \frac{i\,[a]\,x}{\sqrt{n}} + \frac{i\,[b]\,y}{\sqrt{n}} + \frac{i\,[c]\,u}{\sqrt{n}} + \frac{i\,[l]}{\sqrt{n}} \qquad 1 \qquad 1 \qquad (n+1)$$

where $i = \sqrt{-1}$

This fictitious equation is derived from multiplying the expression $[a]\,x + [b]\,y + [c]\,u + [l]$ by $\sqrt{-\frac{1}{n}}$. This expression is at once seen to be the SUM of all the right-hand expressions for the original observation equations. Hence, in practice we first find the SUM expression and then multiply it by $\sqrt{-\frac{1}{n}}$ to form the above mentioned fictitious equation.

Now we form our normal equations from the $(n + 1)$ observation equations and get:—

$$\left([aa] - \frac{a}{n}[a]\right) x + \left([ab] - \frac{a}{n}[b]\right) y + \left([ac] - \frac{a}{n}[c]\right) u + [al] - \frac{a}{n}[l] = 0$$

$$\left([bb] - \frac{b}{n}[b]\right) y + \left([bc] - \frac{b}{n}[c]\right) u + [bl] - \frac{b}{n}[l] = 0$$

$$\left([cc] - \frac{c}{n}[c]\right) u + [cl] - \frac{c}{n}[l] = 0$$

the same result as by method (II).

The second method was used in this adjustment, but the third is considerably shorter and all the work is done by arithmometer.

In the following table are given the five observation equations with z omitted for station Ashton; the sum or fictitious observation is given in the last row with weight $-\frac{1}{5}$. This is reduced to unit weight by multiplying each coefficient by $\sqrt{-\frac{1}{5}} = 0{\cdot}447214\,i$ and the result inserted in the second last row. The normal equations given in the table following are formed from the five observation equations and the fictitious observation equation.

STATION ASHTON

v	$\delta\phi_1$	$\delta\lambda_1$	$\delta\phi_3$	$\delta\lambda_3$	$\delta\phi_4$	$\delta\lambda_4$
4·21					+ 52·913	+106·172
4·3			−151·240	− 68·824	+150·777	+ 68·824
4·5					+254·415	− 2·340
4·6					+192·591	−229·717
·1	+ 156·409	− 82·699			−155·921	+ 82·699
4·0	+ 699·48i	− 36·984 i	− 67·637 i	− 30·779 i	+221·270 i	+ 11·466 i
Sum	+156·409	− 82·699	−151·240	− 68·824	+494·775	+ 25·638

v	$\delta\phi_5$	$\delta\lambda_5$	$\delta\phi_6$	$\delta\lambda_6$	l	Σ	δP	$\sqrt{P}$
4·21					0·000	+159·085	1	1
4·3					− 1·791	− 2·254	1	1
4·5	−254·404	+ 2·340			− 5·390	− 5·379	1	1
4·6			−192·148	+229·717	− 48·437	− 47·994	1	1
4·1					+ 8·525	+ 9·013	1	1
4·0	−113·773 i	+ 1·046 i	− 85·931 i	+102·733 i	− 21·061 i	+ 50·298 i	1	1
Sum	−254·404	+ 2·340	−192·148	+229·717	− 47·093	+112·471	$-\frac{1}{5}$	0·447214i

OBSERVATION EQUATIONS

Ottawa—Groveton Net

Station Pakenham

$v_{1.21} = -z_1$			$+134{\cdot}286\ \delta\phi_1$	$+\ 43{\cdot}090\ \delta\lambda_1$			$0{\cdot}000$
$v_{1.2} = -z_1$			$+233{\cdot}975\ \delta\phi_1$	$+\ 11{\cdot}857\ \delta\lambda_1$	$-234{\cdot}050\ \delta\phi_2$	$-\ 11{\cdot}857\ \delta\lambda_2$	$+\ 8{\cdot}711$
$v_{1.4} = -z_1$			$+156{\cdot}409\ \delta\phi_1$	$-\ 83{\cdot}409\ \delta\lambda_1$	$-155{\cdot}921\ \delta\phi_4$	$+\ 83{\cdot}409\ \delta\lambda_4$	$+11{\cdot}019$

Station Carp

$v_{2.21} = -z_2$			$+192{\cdot}101\ \delta\phi_2$	$+178{\cdot}231\ \delta\lambda_2$			$0{\cdot}000$
$v_{2.49} = -z_2$			$+254{\cdot}987\ \delta\phi_2$	$+\ 39{\cdot}799\ \delta\lambda_2$			$-\ 4{\cdot}480$
$v_{2.3} = -z_2$			$+221{\cdot}537\ \delta\phi_2$	$-\ 13{\cdot}190\ \delta\lambda_2$	$-221{\cdot}454\ \delta\phi_3$	$+\ 13{\cdot}190\ \delta\lambda_3$	$+\ 2{\cdot}892$
$v_{2.1} = -z_2$	$+233{\cdot}975\ \delta\phi_1$	$+\ 12{\cdot}568\ \delta\lambda_1$	$-234{\cdot}050\ \delta\phi_2$	$-\ 12{\cdot}568\ \delta\lambda_2$			$+11{\cdot}892$

Station Bowesville

$v_{3.24} = -z_3$			$+229{\cdot}530\ \delta\phi_3$	$+\ 97{\cdot}972\ \delta\lambda_3$			$0{\cdot}000$
$v_{3.7} = -z_3$			$+162{\cdot}917\ \delta\phi_3$	$-108{\cdot}382\ \delta\lambda_3$	$-162{\cdot}410\ \delta\phi_7$	$+108{\cdot}382\ \delta\lambda_7$	$+\ 2{\cdot}750$
$v_{3.22} = -z_3$			$+\ 60{\cdot}652\ \delta\phi_3$	$-146{\cdot}680\ \delta\lambda_3$			$+\ 3{\cdot}859$
$v_{3.5} = -z_3$			$-\ 74{\cdot}322\ \delta\phi_3$	$-218{\cdot}166\ \delta\lambda_3$	$+\ 74{\cdot}091\ \delta\phi_5$	$+218{\cdot}166\ \delta\lambda_5$	$+\ 4{\cdot}028$
$v_{3.6} = -z_3$			$-\ 84{\cdot}905\ \delta\phi_3$	$-\ 96{\cdot}271\ \delta\lambda_3$	$+\ 84{\cdot}450\ \delta\phi_6$	$+\ 96{\cdot}271\ \delta\lambda_6$	$+\ 0{\cdot}912$
$v_{3.4} = -z_3$			$-151{\cdot}240\ \delta\phi_3$	$-\ 69{\cdot}534\ \delta\lambda_3$	$+150{\cdot}777\ \delta\phi_4$	$+\ 69{\cdot}534\ \delta\lambda_4$	$+16{\cdot}991$
$v_{3.2} = -z_3$	$+221{\cdot}537\ \delta\phi_2$	$-\ 12{\cdot}478\ \delta\lambda_2$	$-221{\cdot}454\ \delta\phi_3$	$+\ 12{\cdot}478\ \delta\lambda_3$			$+12{\cdot}323$
$v_{3.21} = -z_3$			$-172{\cdot}863\ \delta\phi_3$	$+135{\cdot}402\ \delta\lambda_5$			$+18{\cdot}349$

Station Ashton

$v_{4.21} = -z_4$			$+\ 52{\cdot}913\ \delta\phi_4$	$+106{\cdot}172\ \delta\lambda_4$			$0{\cdot}000$
$v_{4.3} = -z_4$	$-151{\cdot}240\ \delta\phi_3$	$-\ 68{\cdot}824\ \delta\lambda_3$	$+150{\cdot}777\ \delta\phi_4$	$+\ 68{\cdot}824\ \delta\lambda_4$			$-\ 1{\cdot}791$
$v_{4.5} = -z_4$			$+254{\cdot}415\ \delta\phi_4$	$-\ 2{\cdot}340\ \delta\lambda_4$	$-254{\cdot}404\ \delta\phi_5$	$+\ 2{\cdot}340\ \delta\lambda_5$	$-\ 5{\cdot}390$
$v_{4.6} = -z_4$			$+192{\cdot}591\ \delta\phi_4$	$-229{\cdot}717\ \delta\lambda_4$	$-192{\cdot}148\ \delta\phi_6$	$+229{\cdot}717\ \delta\lambda_6$	$-48{\cdot}437$
$v_{4.1} = -z_4$	$+156{\cdot}409\ \delta\phi_1$	$-\ 82{\cdot}699\ \delta\lambda_1$	$-155{\cdot}921\ \delta\phi_4$	$+\ 82{\cdot}699\ \delta\lambda_4$			$+\ 8{\cdot}525$

Station North Gower

$v_{5.3} = -z_5$	$-\ 74{\cdot}322\ \delta\phi_3$	$-217{\cdot}456\ \delta\lambda_3$	$+\ 74{\cdot}091\ \delta\phi_5$	$+217{\cdot}456\ \delta\lambda_5$			$0{\cdot}000$
$v_{5.7} = -z_5$			$+249{\cdot}479\ \delta\phi_5$	$-\ 0{\cdot}431\ \delta\lambda_5$	$-249{\cdot}479\ \delta\phi_7$	$+\ 0{\cdot}431\ \delta\lambda_7$	$+\ 0{\cdot}323$
$v_{5.22} = -z_5$			$+335{\cdot}527\ \delta\phi_5$	$-161{\cdot}310\ \delta\lambda_5$			$-\ 5{,}728$
$v_{5.8} = -z_5$			$+\ 76{\cdot}308\ \delta\phi_5$	$-137{\cdot}359\ \delta\lambda_5$	$-\ 75{\cdot}964\ \delta\phi_8$	$+137{\cdot}359\ \delta\lambda_8$	$+\ 0{\cdot}679$
$v_{5.6} = -z_5$			$-221{\cdot}320\ \delta\phi_5$	$-136{\cdot}389\ \delta\lambda_5$	$+220{\cdot}821\ \delta\phi_6$	$+136{\cdot}389\ \delta\lambda_6$	$-\ 6{\cdot}723$
$v_{5.4} = -z_5$	$+254{\cdot}415\ \delta\phi_4$	$-\ 1{\cdot}631\ \delta\lambda_4$	$-254{\cdot}404\ \delta\phi_5$	$+\ 1{\cdot}631\ \delta\lambda_5$			$+\ 7{\cdot}960$

Station Montague

$v_{6.20} = -z_6$			$-371{\cdot}436\ \delta\phi_6$	$-117{\cdot}845\ \delta\lambda_6$			$0{\cdot}000$
$v_{6.4} = -z_6$	$+192{\cdot}591\ \delta\phi_4$	$-229{\cdot}009\ \delta\lambda_4$	$-192{\cdot}148\ \delta\phi_6$	$+229{\cdot}009\ \delta\lambda_6$			$-56{\cdot}094$
$v_{6.3} = -z_6$	$-\ 84{\cdot}905\ \delta\phi_3$	$-\ 95{\cdot}562\ \delta\lambda_3$	$+\ 84{\cdot}450\ \delta\phi_6$	$+\ 95{\cdot}562\ \delta\lambda_6$			$-23{\cdot}531$
$v_{6.5} = -z_6$	$-221{\cdot}320\ \delta\phi_5$	$-135{\cdot}681\ \delta\lambda_5$	$+220{\cdot}821\ \delta\phi_6$	$+135{\cdot}681\ \delta\lambda_6$			$-22{\cdot}944$
$v_{6.22} = -z_6$			$+208{\cdot}957\ \delta\phi_6$	$+\ 27{\cdot}014\ \delta\lambda_6$			$-20{\cdot}743$
$v_{6.8} = -z_6$			$+181{\cdot}810\ \delta\phi_6$	$-\ 66{\cdot}761\ \delta\lambda_6$	$-181{\cdot}400\ \delta\phi_8$	$+\ 66{\cdot}761\ \delta\lambda_8$	$-\ 6{\cdot}784$

Station Ormond

$v_{7.24} = -z_7$			$-\ 3{\cdot}032\ \delta\phi_7$	$+140{\cdot}815\ \delta\lambda_7$			$0{\cdot}000$
$v_{7.23} = -z_7$			$+201{\cdot}370\ \delta\phi_7$	$+\ 39{\cdot}054\ \delta\lambda_7$			$-\ 0{\cdot}010$
$v_{7.10} = -z_7$			$+195{\cdot}425\ \delta\phi_7$	$-\ 70{\cdot}054\ \delta\lambda_7$	$-195{\cdot}019\ \delta\phi_{10}$	$+\ 70{\cdot}054\ \delta\lambda_{10}$	$-\ 2{\cdot}532$
$v_{7.9} = -z_7$			$+104{\cdot}327\ \delta\phi_7$	$-185{\cdot}028\ \delta\lambda_7$	$-103{\cdot}979\ \delta\phi_9$	$+185{\cdot}028\ \delta\lambda_9$	$-\ 4{\cdot}222$
$v_{7.8} = -z_7$			$-\ 89{\cdot}789\ \delta\phi_7$	$-126{\cdot}766\ \delta\lambda_7$	$+\ 89{\cdot}384\ \delta\phi_8$	$+126{\cdot}766\ \delta\lambda_8$	$-\ 2{\cdot}802$
$v_{7.22} = -z_7$			$-340{\cdot}322\ \delta\phi_7$	$-169{\cdot}683\ \delta\lambda_7$			$+\ 9{\cdot}202$
$v_{7.5} = -z_7$	$+249{\cdot}479\ \delta\phi_5$	$+\ 0{\cdot}279\ \delta\lambda_5$	$-249{\cdot}479\ \delta\phi_7$	$-\ 0{\cdot}279\ \delta\lambda_7$			$-\ 0{\cdot}549$
$v_{7.3} = -z_7$	$+162{\cdot}917\ \delta\phi_3$	$-107{\cdot}672\ \delta\lambda_3$	$-162{\cdot}410\ \delta\phi_7$	$+107{\cdot}672\ \delta\lambda_7$			$-\ 4{\cdot}558$

Station Groveton

$v_{8.9} = -z_8$			$+252{\cdot}179\ \delta\phi_8$	$+\ 58{\cdot}197\ \delta\lambda_8$	$-252{\cdot}476\ \delta\phi_9$	$-\ 58{\cdot}197\ \delta\lambda_9$	$0{\cdot}000$
$v_{8.19} = -z_8$			$-109{\cdot}311\ \delta\phi_8$	$-165{\cdot}056\ \delta\lambda_8$			$+10{\cdot}806$
$v_{8.6} = -z_8$	$+181{\cdot}810\ \delta\phi_6$	$-\ 66{\cdot}054\ \delta\lambda_6$	$-181{\cdot}400\ \delta\phi_8$	$+\ 66{\cdot}054\ \delta\lambda_8$			$+12{\cdot}879$
$v_{8.5} = -z_8$	$+\ 76{\cdot}308\ \delta\phi_5$	$-136{\cdot}651\ \delta\lambda_5$	$-\ 75{\cdot}964\ \delta\phi_8$	$+136{\cdot}651\ \delta\lambda_8$			$+\ 2{\cdot}197$
$v_{8.22} = -z_8$			$+\ 29{,}014\ \delta\phi_8$	$+227{\cdot}057\ \delta\lambda_8$			$-\ 4{\cdot}442$
$v_{8.7} = -z_8$	$-\ 89{\cdot}789\ \delta\phi_7$	$-126{\cdot}059\ \delta\lambda_7$	$+\ 89{\cdot}384\ \delta\phi_8$	$+126{\cdot}059\ \delta\lambda_8$			$-\ 2{\cdot}063$

Station Dundela

$v_{9.8} = -z_9$	$+252{\cdot}179\ \delta\phi_8$	$+\ 58{\cdot}903\ \delta\lambda_8$	$-252{\cdot}476\ \delta\phi_9$	$-\ 58{\cdot}903\ \delta\lambda_9$			$0{\cdot}000$
$v_{9.22} = -z_9$			$-225{\cdot}992\ \delta\phi_9$	$+\ 93{\cdot}437\ \delta\lambda_9$			$+\ 4{\cdot}712$
$v_{9.7} = -z_9$	$+104{\cdot}327\ \delta\phi_7$	$-184{\cdot}321\ \delta\lambda_7$	$-103{\cdot}979\ \delta\phi_9$	$+184{\cdot}321\ \delta\lambda_9$			$-\ 4{\cdot}240$

Station Osnabruck

$v_{10.7} = -z_{10}$	$+195{\cdot}425\ \delta\phi_7$	$-\ 69{\cdot}345\ \delta\lambda_7$	$-195{\cdot}019\ \delta\phi_{10}$	$+\ 69{\cdot}345\ \delta\lambda_{10}$			$0{\cdot}000$
$v_{10.23} = -z_{10}$			$+\ 46{\cdot}672\ \delta\phi_{10}$	$+206{\cdot}716\ \delta\lambda_{10}$			$+\ 3{\cdot}339$
$v_{10.28} = -z_{10}$			$+265{\cdot}908\ \delta\phi_{10}$	$+112{\cdot}482\ \delta\lambda_{10}$			$+\ 5{\cdot}435$

Station Lavant

$v_{15.4} =$	$-120{\cdot}378\ \delta\phi_4$	$-\ 19{\cdot}610\ \delta\lambda_4$					$+\ 0{\cdot}567$

Station Elizabethtown

$v_{19.6} =$	$+\ 66{\cdot}471\ \delta\phi_6$	$-100{\cdot}783\ \delta\lambda_6$					$+\ 8{\cdot}257$
$v_{19.8} =$	$-109{\cdot}311\ \delta\phi_8$	$-164{\cdot}352\ \delta\lambda_8$					$+\ 8{\cdot}618$

Station Elmsley

$v_{20.6} =$	$-371{\cdot}436\ \delta\phi_6$	$-117{\cdot}138\ \delta\lambda_6$					$+15{\cdot}574$

Station King Mountain

$v_{21.8} =$	$-172{\cdot}863\ \delta\phi_3$	$+136{\cdot}114\ \delta\lambda_3$					$+10{\cdot}651$
$v_{21.4} =$	$+\ 52{\cdot}913\ \delta\phi_4$	$+106{\cdot}883\ \delta\lambda_4$					$+\ 8{\cdot}520$
$v_{21.2} =$	$+192{\cdot}101\ \delta\phi_2$	$+178{\cdot}943\ \delta\lambda_2$					$+\ 3{\cdot}239$

OBSERVATION EQUATIONS—*Concluded*

OTTAWA—GROVETON NET

STATION NORTH MOUNTAIN

$v_{22.7} = -340{\cdot}322\ \delta\phi_7 \quad -168{\cdot}975\ \delta\lambda_7 \quad + 6{\cdot}124$
$v_{22.9} = -225{\cdot}992\ \delta\phi_9 \quad + 94{\cdot}144\ \delta\lambda_9 \quad + 0{\cdot}700$
$v_{22.8} = + 29{\cdot}014\ \delta\phi_8 \quad +227{\cdot}764\ \delta\lambda_8 \quad - 9{\cdot}670$
$v_{22.6} = +208{\cdot}956\ \delta\phi_6 \quad + 27{\cdot}722\ \delta\lambda_6 \quad - 7{\cdot}150$
$v_{22.5} = +335{\cdot}527\ \delta\phi_5 \quad -160{\cdot}602\ \delta\lambda_5 \quad - 9{\cdot}260$
$v_{22.3} = + 60{\cdot}652\ \delta\phi_3 \quad -145{\cdot}970\ \delta\lambda_3 \quad - 6{\cdot}181$

STATION ROXBORO

$v_{23.10} = + 46{\cdot}672\ \delta\phi_{10} \quad +207{\cdot}524\ \delta\lambda_{10} \quad - 1{\cdot}835$
$v_{23.7} = +201{\cdot}370\ \delta\phi_7 \quad + 39{\cdot}764\ \delta\lambda_7 \quad - 3{\cdot}508$

STATION NAVAN

$v_{24.7} = - 3{\cdot}032\ \delta\phi_7 \quad +141{\cdot}526\ \delta\lambda_7 \quad - 0{\cdot}710$
$v_{24.3} = +229{\cdot}530\ \delta\phi_3 \quad + 98{\cdot}683\ \delta\lambda_3 \quad - 7{\cdot}778$

STATION BONVILLE

$v_{28.10} = +265{\cdot}908\ \delta\phi_{10} \quad +113{\cdot}190\ \delta\lambda_{10} \quad + 1{\cdot}300$

STATION OTTAWA

$v_{49.2} = +254{\cdot}987\ \delta\phi_2 \quad + 40{\cdot}510\ \delta\lambda_2 \quad - 3{\cdot}142$

NORMAL EQUATIONS

When the reduced partial normal equations have been formed for each station the normal equation for any unknown is obtained by collecting and adding together the partial normal equations of that unknown.

$\delta\phi_1$	$\delta\lambda_1$	$\delta\phi_3$	$\delta\lambda_3$	$\delta\phi_4$	$\delta\lambda_4$	$\delta\phi_5$	$\delta\lambda_5$	$\delta\phi_6$	$\delta\lambda_6$	l	Σ	sum—Σ
+19571·053	−10347·911	+ 4731·073	+ 2152·929	−39864·842	+12132·844	+ 7958·194	− 73·166	+ 6010·702	− 7185·968	+ 2806·562	− 2108·530	0·000
	+ 5471·308	− 2501·487	− 1138·331	+21077·960	− 6415·066	− 4207·781	+ 38·685	− 3178·072	+ 3799·477	− 1483·929	+ 1114·855	− 0·002
		+18298·774	+ 8327·143	− 7837·474	− 9633·416	− 7695·264	+ 70·748	− 5812·115	+ 6948·552	− 1153·632	+ 3742·900	+ 0·002
			+ 3789·396	− 3566·607	− 4383·831	− 3501·819	+ 32,195	− 2644,870	+ 3162·019	− 524·973	+ 1703·251	0·000
				+102702·720	−44273·395	−39549,642	+ 363·883	−17992·023	+21509·696	− 7638·928	−15068·652	0·000
					+75492·268	+ 1899·827	− 17·469	+45124·947	−53947·837	+11962·646	+27941·517	+ 0·001
						+51777·100	− 476·299	− 9776·628	+11688·242	− 1024·936	+ 7090·993	+ 0·001
							+ 4·381	+ 89,884	− 107,459	+ 9·417	− 65·199	− 0·001
								+29536·717	−35311·713	+ 7497·280	+13544·109	0·000
									+42215·831	− 8963·143	−16192·302	− 0·001

In the above table the first line is the partial normal equation for $\delta\varphi_1$ for the station Ashton. A partial normal equation for $\delta\varphi_1$ occurs for the observations at station No. 1 and at every station from which an observation to the station No. 1 has been made. To pick these out it is necessary only to select those groups of reduced partial normal equations which have a $\delta\varphi_1$ heading. Then the normal equation for $\delta\varphi_1$ is the sum of these separate equations. The normal equations for all of the $\delta\varphi$'s and $\delta\lambda$'s are formed in the same manner.

The normal equations with the coefficients and absolute terms divided throughout by 10 and the symbols $\Delta\varphi$ and $\Delta\lambda$ inserted instead of 100 $\delta\varphi$ and 100 $\delta\lambda$ are shown in the following table. The numbers can now be handled more easily and the solution will give 100 times the value of the required most probable corrections.

The reduced normal equations and the evaluation of the unknowns are shown in the two next tables. The most probable values of the corrections to the preliminary co-ordinates are given in the third last row, and result from dividing the values of the $\Delta\varphi$'s and $\Delta\lambda$'s by 100.

$\triangle\phi_1$	$\triangle\lambda_1$	$\triangle\phi_2$	$\triangle\lambda_2$	$\triangle\phi_3$	$\triangle\lambda_3$	$\triangle\phi_4$	$\triangle\lambda_4$	$\triangle\phi_5$	$\triangle\lambda_5$	$\triangle\phi_6$	$\triangle\lambda_6$	$\triangle\phi_7$	$\triangle\lambda_7$	$\triangle\phi_8$
+66·1107	− 7·6500	− 94·0108	− 14·8880	+ 17·6847	+ 1·3814	− 36·9834	+ 10·5914	+ 7·9582	− 0·0732	+ 6·0107	− 7·1860			
	+ 14·2741	− 9·3028	− 1·0152	− 1·8057	− 1·1798	+ 32·6039	− 12·5808	− 4·2078	+ 0·0387	− 3·1781	+ 3·7995			
		+339·9495	+ 67·6531	− 67·0909	+ 15·1414	− 16·3398	+ 4·5818	− 2·0517	− 6·0415	− 2·3386	− 2·6660	+ 4·4975	− 3·0013	
			+ 58·3318	+ 15·9365	− 1·5769	− 0·3811	+ 0·4381	+ 0·1156	+ 0·3403	+ 0·1317	+ 0·1502	− 0·2533	+ 0·1691	
				+364·6751	− 6·4149	− 20·0207	− 21·2230	− 21·3732	− 30·0481	− 12·8861	− 0·3381	− 54·1149	+ 43·9955	− 5·3282
					+214,3778	+ 5·6478	− 9·5079	− 22·8918	− 94·1294	− 4·5820	− 0·7432	+ 13,4367	− 21·5542	− 4·4393
						+240·9415	− 72·8539	−109·5774	+ 10·1980	− 70·2044	+ 48·3023	+ 13·6395	− 2·0609	+ 9·0438
							+139,8759	− 6·7062	− 7·1539	+ 93·5099	− 95,6406	+ 1·3438	− 0·9419	− 6·9444
								+557·8858	− 33·2882	−115·2865	− 43·3169	−100·3112	+ 8·8599	− 17·8340
									+201·3222	− 47·1916	− 29·4854	− 6·5639	− 5·8022	+ 14·0588
										+594·5753	+ 54·1209	+ 13·6169	+ 2·6598	− 59·2786
											+177·9040	+ 6·6370	− 2·7018	+ 35·0128
												+558·1076	+ 51·9651	− 24·0787
													+207·7620	− 4·0646
														+217·4573

NORMAL EQUATIONS—*Continued*

$\triangle\lambda_8$	$\triangle\phi_9$	$\triangle\lambda_9$	$\triangle\phi_{10}$	$\triangle\lambda_{10}$	l
					+ 529·7306
					− 199·5440
					− 399·2644
					− 49·5603
+ 0·0646	+ 2·1175	− 3·7680	+ 3·9715	− 1·4266	−1204·4797
+ 7·7477	− 1·3995	+ 2·4903	− 2·6248	+ 0·9429	+ 406·7242
− 7·9673					−1095·7463
+ 2·5855					+2176·6058
+ 7·7638	+ 6·4536	− 5·0299	+ 6·0817	− 2·1846	− 632·3420
− 20·8563	− 5·7466	− 1·3319	+ 0·0068	− 0·0024	+ 270·7553
+ 4·0136	+ 7·6504	+ 1·7635			+ 164·6311
− 10·3675	− 2·7795	− 0·6407			−2567·0390
− 6·8697	− 9·6888	+ 38·0054	− 92·2652	+ 4·9433	− 598·9013
− 14·7313	− 6·1204	− 49·8736	+ 23·4608	+ 1·5791	− 101·7416
+ 53·5231	− 77·0521	− 49·9564	+ 2·1790	− 0·7827	− 826·0239
+202·2174	+ 2·4107	− 9·7307	+ 3·0902	− 1·1101	− 608·0089
	+126·1989	− 8·7850	− 2·5347	+ 0·9105	+ 49·2703
		+ 71·8498	+ 4·5105	− 1·6202	− 77·6485
			+212·4745	+ 38·6329	+ 187·7678
				+ 70·0015	− 19·7742

FUNCTION EQUATIONS FOR

Lengths of sides		Corrections to directions		Corrections to assumed positions			
1·2	5·7	5·3	9·7	$\triangle\phi_3$	$\triangle\lambda_3$	$\triangle\phi_9$	$\triangle\lambda_9$
+ 0·0023							
− 0·0217							
− 0·0022							
+ 0·0217							
		−0·0619		+0·0010			
		−0·1812			+0·0010		
		−0·0424					
	.....	+0·0308					
	−0·0218	+0·2535					
		−0·0368					
	.....	−0·0227					
	+0·0218	+0·0416	+0·0596				
		−0·0001	−0·1229				
		+0·0127	−0·0841				
		−0·0229	+0·0196				
			+0·0902			+0·0010	
			+0·1114				+0·0010

REDUCED NORMAL EQUATIONS

$\Delta\phi_1$	$\Delta\lambda_1$	$\Delta\phi_2$	$\Delta\lambda_2$	$\Delta\phi_3$	$\Delta\lambda_3$	$\Delta\phi_4$	$\Delta\lambda_4$	$\Delta\phi_5$	$\Delta\lambda_5$	$\Delta\phi_6$	$\Delta\lambda_6$	$\Delta\phi_7$	$\Delta\lambda_7$	$\Delta\phi_8$	$\Delta\lambda_8$	$\Delta\phi_9$	$\Delta\lambda_9$	$\Delta\phi_{10}$	$\Delta\lambda_{10}$	$l.$
−1·0	+0·1157	+1·4220	+0·2252	−0·2675	−0·0209	+0·5594	−0·1602	−0·1204	+0·0011	−0·0909	+0·1087									−8·0128
	−1·0	+1·5073	+0·2045	−0·0180	+0·0762	−2·1155	+0·8481	+0·2455	−0·0023	+0·1854	−0·2217									+10·3255
		−1·0	−0·2409	+0·2365	−0·0885	+0·1492	−0·0144	−0·0245	+0·0347	−0·0140	+0·0478	−0·0256	+0·0171							−0·8282
			−1·0	−0·6781	+0·1182	−0·0769	+0·0024	−0·0045	−0·0407	−0·0087	−0·0263	+0·0302	−0·0202							−0·1443
				−1·0	−0·0014	+0·0581	+0·0703	+0·0684	+0·0991	+0·0428	+0·0038	+0·1581	−0·1294	+0·0162	−0·0002	−0·0064	+0·0114	−0·0120	+0·0043	+3·9833
					−1·0	−0·0534	+0·0509	+0·1113	+0·4397	+0·0238	−0·0024	−0·0610	+0·1001	+0·0209	−0·0365	+0·0066	−0·0118	+0·0124	−0·0045	−1·7657
						−1·0	+0·2803	+0·6319	−0·0785	+0·4002	−0·2367	−0·0692	−0·0067	−0·0581	+0·0542	−0·0013	+0·0023	−0·0024	+0·0009	+3·7684
							−1·0	+0·3588	+0·0934	−0·6290	+0·7151	−0·0111	−0·0115	+0·0440	−0·0056	−0·0012	+0·0021	−0·0022	+0·0008	−15·2017
								−1·0	+0·0882	+0·2765	+0·1004	+0·2005	−0·0223	+0·0312	−0·0075	−0·0139	+0·0112	−0·0134	+0·0048	+1·1076
									−1·0	+0·3359	+0·2941	+0·0990	+0·0667	−0·0602	+0·1086	+0·0369	+0·0071	+0·0013	−0·0005	−3·1266
										−1·0	−0·1986	+0·0346	−0·0067	+0·1148	+0·0087	−0·0163	+0·0003	−0·0038	+0·0014	+2·7061
											−1·0	+0·0786	+0·0618	−0·5673	+0·1599	+0·0719	+0·0215	−0·0046	+0·0017	+10·4747
												−1·0	−0·1157	+0·0492	+0·0166	+0·0164	−0·0683	+0·1712	−0·0079	+1·8509
													−1·0	−0·0158	+0·0770	+0·0335	+0·2782	−0·1719	−0·0075	−1·0931
														−1·0	−0·3315	+0·3953	+0·2522	+0·0138	+0·0037	+2·9236
															−1·0	−0·1397	−0·0100	−0·0289	+0·0042	+3·1842
																−1·0	+0·3092	+0·0515	−0·0099	+1·0168
																	−1·0	−0·5282	+0·0428	+4·4141
																		−1·0	−0·2205	−0·5603
																			−1·0	+0·9516

EVALUATION OF UNKNOWNS

$\Delta\varphi_1$	$\Delta\lambda_1$	$\Delta\varphi_2$	$\Delta\lambda_2$	$\Delta\varphi_3$	$\Delta\lambda_3$	$\Delta\varphi_4$	$\Delta\lambda_4$	$\Delta\varphi_5$	$\Delta\lambda_5$	$\Delta\varphi_6$	$\Delta\lambda_6$	$\Delta\varphi_7$	$\Delta\lambda_7$
−8· 128	+10·3255	−0·8282	−0·1443	+3·9833	−1·7657	+3·7684	−15·2017	+1·1076	−3·1266	+2·7061	+10·4747	+1·8509	−1·0931
				+0·0041	−0·0042	+0·0008	+0·0007	+0·0046	−0·0005	+0·0013	+0·0016	−0·0076	−0·0071
				+0·0093	−0·0095	+0·0018	+0·0017	+0·0103	−0·0010	+0·0029	+0·0036	−0·1319	+0·1324
				+0·0555	−0·0572	+0·0111	+0·0101	+0·0544	+0·0345	+0·0017	+0·1048	−0·3322	+1·3523
				−0·0159	+0·0163	−0·0032	−0·0029	−0·0344	+0·0911	−0·0403	+0·1776	+0·0406	+0·0829
				−0·0006	−0·1028	+0·1528	−0·0157	−0·0211	+0·3059	+0·0245	+0·4504	+0·0467	+0·2169
				+0·0676	+0·0874	−0·2431	+0·1844	+0·1305	−0·2521	+0·4806	−2·3746	+0·2060	−0·0660
		+0·0106	−0·0125	−0·0800	+0·0619	−0·0041	−0·0071	−0·0138	+0·0412	−0·0042	+0·0382	−0·0715	+0·6183
		−0·0409	+0·0484	+0·2532	−0·0977	−0·1109	−0·0178	+0·3210	+0·1584	+0·0555	+0·1259	+1·6010	
+0·9785	−1·9955	+0·4306	−0·2371	+0·0341	−0·0219	−2·1310	+6·4374	+ ·9040	+2·6477	−1·7882	+9·0022		
−0·1309	+0·2670	−0·0202	−0·0125	+0·0617	+0·0343	+0·5762	−0·9057	+0·3982	+0·4836	+1·4399			
+0·0004	−0·0009	+0·0133	−0·0156	+0·0379	+0·1680	−0·0300	+0·0357	+0·0337	+0·3822				
−0·3485	+0·7107	−0·0710	−0·0129	+0·1980	+0·3223	+1·8294	+1·0337	+2·8950					
+1·3525	−7·1599	+0·1213	−0·0205	−0·5934	−0·4295	−2·3664	−8·4422						
+0·8122	−3·0713	+0·2166	−0·1117	+0·0843	−0·0775	+1·4518							
+0·0392	−0·1429	+0·1661	−0·2216	+0·0026	−1·8758								
−1·0972	−0·0737	+0·9699	−2·7813	+4·1017									
−0·7931	−0·7201	+0·8482	−3·5216										
+2·5828	+2·7377	+1·8163											
+0·1003	+0·8766												
−4·5166													
−0·045	+ 0·009	+0·018	−0·035	+0·041	−0·019	+0·015	− 0·084	+0·029	+0·004	+0·014	+ 0·090	+0·016	+0·006
$\delta\varphi_1$	$\delta\lambda_1$	$\delta\varphi_2$	$\delta\lambda_2$	$\delta\varphi_3$	$\delta\lambda_3$	$\delta\varphi_4$	$\delta\lambda_4$	$\delta\varphi_5$	$\delta\lambda_5$	$\delta\varphi_6$	$\delta\lambda_6$	$\delta\varphi_7$	$\delta\lambda_7$

EVALUATION OF UNKNOWNS—*Continued*

$\Delta\varphi_8$	$\Delta\lambda_8$	$\Delta\varphi_9$	$\Delta\lambda_9$	$\Delta\varphi_{10}$	$\Delta\lambda_{10}$
+2·9236	+3·1842	+1·0168	+4·4141	−0·5603	+0·9516
+0·0035	+0·0040	−0·0094	+0·0408	−0·2098	+0·9516
−0·0106	+0·0223	−0·0397	+0·4067	−0·7701	
+1·2263	−0·0486	+1·5034	+4·8616		
+0·9769	−0·3452	+2·4711			
−0·9339	+2·8167				
+4·1858					

Precision Formulæ

As a test of the accuracy of the triangulation the weights of two sides, and of two corrections to observed directions, in addition to the geographical co-ordinates of two stations, will be determined. Referring to equation (6) we see that the function equations are of the form

$$\delta F = f_1 x + f_2 y + f_3 z + \quad . \quad . \quad .$$

where $x, y, z \quad . \quad . \quad .$ are the unknowns of the normal equations. In this case the unknowns are changes in the geographical positions, hence all function equations are of the form

$$\delta F = f_1 \delta\phi_1 + f_2 \delta\lambda_1 + f_3 \delta\phi_2 + f_4 \delta\lambda_2 + \quad . \quad . \quad .$$

Comparing this with the equations on page 50, we see that the function equation for the weight of a side is

$$\delta s_{1\cdot 2} = E\delta\phi_1 + F\delta\phi_2 + G\,(\delta\lambda_1 - \delta\lambda_2)$$

The function equation for the reciprocal of the weight of a correction to an observed direction is obtained as follows. We have from the observation equation

$$v = -z + A\delta\phi_1 + B\delta\phi_2 + C\,(\delta\lambda_2 - \delta\lambda_1) + \text{abs. term.}$$

This equation contains the orientation factor z which has been eliminated from the body of the normal equations. Its value in terms of $\delta\varphi$'s and $\delta\lambda$'s obtained from the normal equation for z must be substituted, then

$$v = f_1 \delta\phi_1 + f_2 \delta\lambda_1 + f_3 \delta\phi_2 + f_4 \delta\lambda_2 + \quad . \quad . \quad . \quad .$$

In the determination of the function equation of the geographical co-ordinates all of the f's are equal to zero except one which is equal to unity.

For the application of these equations the distances Pakenham to Carp and North Gower to Ormond, the corrections to observed directions North Gower to Bowesville and Dundela to Ormond and to the geographical co-ordinates of Bowesville and Dundela have been chosen.

The function equations in the order mentioned are:—

$$\begin{aligned}
\delta s_{1\cdot 2} &= +\,2{\cdot}34\,\delta\phi_1 - 21{\cdot}71\,\delta\lambda_1 - 2{\cdot}21\,\delta\phi_2 + 21{\cdot}71\,\delta\lambda_2 \\
\delta s_{5\cdot 7} &= +\,0{\cdot}05\,\delta\phi_5 - 21{\cdot}85\,\delta\lambda_5 + 0{\cdot}08\,\delta\phi_7 + 21{\cdot}85\,\delta\lambda_7 \\
\delta v_{5\cdot 3} &= -\,61{\cdot}93\,\delta\phi_3 - 181{\cdot}21\,\delta\lambda_3 - 42{\cdot}40\,\delta\phi_4 + 0{\cdot}27\,\delta\lambda_4 + 30{\cdot}81\,\delta\phi_5 \\
&\qquad + 253{\cdot}52\,\delta\lambda_5 - 36{\cdot}80\,\delta\phi_6 - 22{\cdot}73\,\delta\lambda_6 + 41{\cdot}58\,\delta\phi_7 \\
&\qquad - 0{\cdot}07\,\delta\lambda_7 + 12{\cdot}66\,\delta\phi_8 - 22{\cdot}89\,\delta\lambda_8 \\
\delta v_{9\cdot 7} &= +\,69{\cdot}55\,\delta\phi_7 - 122{\cdot}88\,\delta\lambda_7 - 84{\cdot}06\,\delta\phi_8 - 19{\cdot}63\,\delta\lambda_8 + 90{\cdot}17\,\delta\phi^9 \\
&\qquad + 111{\cdot}37\,\delta\lambda_9 \\
\delta\phi_3 &= 1\,\delta\phi_3 \\
\delta\lambda_3 &= 1\,\delta\lambda_3 \\
\delta\phi_9 &= 1\,\delta\phi_9 \\
\delta\lambda_9 &= 1\,\delta\lambda_9
\end{aligned}$$

The reciprocal of the weight of each of these functions is found by attaching these equations in vertical columns to the right hand side of the body of the collected normal equations, operating upon them in the same manner as upon the absolute terms and forming the several products. Since the co-efficients of the normal equations have for convenience been divided throughout by 1000 those in the function equations will likewise have to be divided by 1000. The products formed will then be $\frac{1}{1000}$ of their proper value.

The function equations with coefficients divided throughout by 1000 are shown attached to the normal equations in the table on page 57. The products, multiplied by 1000, from each elimination are shown in the table on page 59.

The probable error of the function is obtained from the probable error, r, of an observation of weight unity and the weight of the function p, thus $p.\ e. = \frac{r}{p_F{}^{\frac{1}{2}}}$. The computation of the probable errors of the various functions is shown at the bottom of the table, for which the headings are to be read from the bottom upwards.

The values of the most probable corrections as given in the table on page 57 give all the data required for the evaluation of the orientation factors, corrections to observed directions and the corrections to azimuths and distances corresponding to the preliminary positions.

Evaluation of Final Values

After the normal equations are solved for $\Delta\varphi$, $\Delta\lambda$, etc., the values of the several z's are found by the following plan. According to the theory given on page 52 the value of z at any point is given by the equation $nz + (a)\ x + (b)\ y + (c)\ u + (l) = 0$, an equation, the left hand of which is formed by adding nz to the SUM of the observation equations as given by the bottom line of the table on page 53. In the same table the number of observations is five, hence upon division by 5,—

$$\begin{aligned} z_4 &= +31{\cdot}282\ \delta\phi_1 - 16{\cdot}540\ \delta\lambda_1 - 30{\cdot}248\ \delta\phi_3 - 13{\cdot}765\ \delta\lambda_3 \\ &\quad + 98{\cdot}955\ \delta\phi_4 + 5{\cdot}128\ \delta\lambda_4 - 50{\cdot}881\ \delta\phi_5 + 0{\cdot}468\ \delta\lambda_5 \\ &\quad - 38{\cdot}430\ \delta\phi_6 + 45{\cdot}944\ \delta\lambda_6 \qquad\qquad - 9{\cdot}419 \\ &= -8''{\cdot}777 \end{aligned}$$

Knowing the value of z we proceed next to the observation equations. Selecting the observation equation for the line Ashton (4) to King Mountain (21) as an example, we get, since $\delta\varphi_{21} = \delta\lambda_{21} = 0$,

$$\begin{aligned} v_{4\cdot21} &= -z_4 + \delta\alpha_{4\cdot21} + \text{abs. term.} \\ &= -z_4 + 52{\cdot}913\ \delta\phi_4 + 106{\cdot}172\ \delta\lambda_4 + \text{abs. term} \\ &= +8{\cdot}777 + \left\{52{\cdot}913\ (+{\cdot}015) + 106{\cdot}172\ (-0{\cdot}084)\right\} + 0{\cdot}0 \\ &= +8{\cdot}777 - 8{\cdot}124 = 0''{\cdot}653 \end{aligned}$$

and $\delta\alpha_{4\cdot21} = -8{\cdot}124''$

Referring to the table of coefficients for the station Ashton and supplying the values of E and G we have,—

$$\begin{aligned} -\delta S_{4\cdot21} &= +29{\cdot}134\ \delta\phi_4 - 7{\cdot}222\ \delta\lambda_4 \\ &= +29{\cdot}134\ (+0{\cdot}015) - 7{\cdot}222\ (-0{\cdot}084) \\ &= 1{\cdot}044 \end{aligned}$$

Using the above values we have finally,—

Orientation factor — station Ashton	$= z_4$	=	$-8''{\cdot}777$
Observed direction — Ashton to King Mountain		=	0° 00′ 00″
Correction from adjustment	$= v_{4\cdot21}$	=	$+0{\cdot}653$
Final direction — Ashton to King Mountain		=	0° 00′ 00″ $+0{\cdot}653$

Station	King Mountain				Ashton			
	ϕ		λ		ϕ		λ	
	° ′ ″		° ′ ″		° ′ ″		° ′ ″	
Preliminary co-ordinates	45 29 21·427		75 51 49·475		45 09 05·587		76 01 55·202	
Correction from adjustment	.....		.....			$+0{\cdot}015$		$-0{\cdot}084$
Final co-ordinates	45 29 21·427		75 51 49·475		45 09 05·602		76 01 55·118	

			° ′ ″
Preliminary azimuth — Ashton to King Mountain (Table on p. 49)		=	19 18 21·277
Correction from adjustment	$= \delta\alpha_{4\cdot21}$	=	$-8{\cdot}124$
Final azimuth — Ashton to King Mountain		=	19 18 13·153

The correction for the distance as given above is in metres. To obtain the equivalent value to add to the logarithmic distance, we have $\delta \log s = \mu \frac{\delta s}{s}$, where $\delta \log s$ is the required correction, μ is the modulus of common logarithms, δs is correction in metres and s is distance in metres. The logarithmic computation is as follows:—

$\log \mu$	=	$9 \cdot 6377843$
$\log \delta s_{4 \cdot 21}$	=	$0 \cdot 0187005\ n$
		$9 \cdot 6564848\ n$
$\log s$	=	$4 \cdot 5997274$
$\log (\delta \log s)$	=	$5 \cdot 0567574\ n$
$\delta \log s$	=	$-\ 0 \cdot 0000114$
$\log s$	=	$4 \cdot 5997274$
$\therefore \log S$	=	$4 \cdot 5997160$

The corrections to observed directions resulting from the figure adjustment indicated by the preceding observations are as follows:—

TABLE OF CORRECTIONS TO OBSERVED DIRECTIONS

OTTAWA—GROVETON NET

Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction	Number of direction	Correction to direction
1·21	+0·105	5·3	+0·729	8·9	−0·112	20·21	.....
2	+0·251	7	+0·193	19	−1·577	6	−0·169
4	−0·355	22	−0·017	6	+0·540		
Σv =	+0·001	8	−0·376	5	+1·329	21·24	.....
		6	−1·694	22	−0·035	3	+0·977
2·21	−0·693	4	+1·168	7	−0·142	4	+0·336
49	+0·804	Σv =	+0·003	Σv =	+0·003	2	+0·434
3	+0·099						
1	−0·210	6·20	−0·264	9·8	−0·103	22·7	−0·335
Σv =	0·000	.4	−0·506	22	+0·495	9	−0·337
		3	+0·128	7	−0·390	8	−2·074
3·24	−0·967	5	+0·938	Σv =	+0·002	6	−1·730
7	+1·025	22	+0·156			5	−0·172
22	+0·617	8	−0·455	10·7	+0·154	3	−0·921
5	−0·369	Σv =	−0·003	23	+0·223		
6	+0·591			28	−0·377	23·26	.....
4	+0·016	7·24	−1·633	Σv =	0·000	10	−0·134
2	−1·085	23	+1·017			7	−0·047
21	+0·173	10	+0·006	15·20	.....	24·49	.....
Σv =	+0·001	9	+0·375	4	+0·409	7	+0·091
		8	−0·125			3	−0·242
4·21	+0·653	22	+0·310	19·20	.....		
3	−1·427	5	+0·265	6	+0·117	28·29	.....
5	+0·031	3	−0·214	8	−0·576	10	+0·305
6	+0·510	Σv =	+0·001				
1	+0·234					49·21	.....
Σv =	+0·001					2	+0·030

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS

Ottawa—Groveton Net

Station occupied	Number of direction	Object observed	Observed direction reduced to sea level	Seconds of adjusted direction
			° ′ ″	″
Pakenham	1·21	King Mountain	359 59 60·00	59·895
	2	Carp	20 27 31·43	31·681
	4	Ashton	61 39 55·87	55·515
Carp	2·21	King Mountain	359 59 60·00	59·307
	49	Ottawa	40 10 39·81	40·614
	3	Bowesville	57 26 18·97	19·069
	1	Pakenham	228 45 37·24	37·030
Bowesville	3·24	Navan	359 59 60·00	59·033
	7	Ormond	74 29 29·23	30·255
	22	North Mountain	105 01 18·43	19·047
	5	North Gower	134 54 52·93	52·561
	6	Montague	153 26 18·92	19·511
	4	Ashton	178 31 50·89	50·906
	2	Carp	216 10 56·52	55·435
	21	King Mountain	259 29 49·66	49·833
Ashton	4·21	King Mountain	359 59 60·00	60·653
	3	Bowesville	37 36 06·08	04·653
	5	North Gower	71 12 52·63	52·661
	6	Montague	129 57 03·17	03·680
	1	Pakenham	287 46 47·70	47·934
North Gower	5·3	Bowesville	359 59 60·00	60·729
	7	Ormond	76 23 46·29	46·483
	22	North Mountain	110 33 44·91	44·893
	8	Groveton	144 55 27·21	26·834
	6	Montague	215 35 08·17	06·476
	4	Ashton	257 13 44·67	45·838
Montague	6·20	Elmsley	359 59 60·00	59·736
	4	Ashton	83 18 30·90	30·394
	3	Bowesville	145 52 01·36	01·488
	5	North Gower	162 55 39·99	40·928
	22	North Mountain	193 22 58·39	58·546
	8	Groveton	231 05 50·79	50·335
Ormond	7·24	Navan	359 59 60·00	58·367
	23	Roxboro	75 16 38·74	39·757
	10	Osnabruck	117 30 00·64	00·646
	9	Dundela	159 02 30·78	31·155
	8	Groveton	207 37 10·71	10·585
	22	North Mountain	235 48 41·15	41·460
	5	North Gower	271 00 30·81	31·075
	3	Bowesville	314 11 24·49	24·276
Groveton	8·9	Dundela	359 59 60·00	59·888
	19	Elizabethtown	133 29 28·41	26·833
	6	Montague	225 33 28·00	28·540
	5	North Gower	266 43 39·76	41·089
	22	North Mountain	293 21 54·36	54·325
	7	Ormond	314 48 42·235	42·093
Dundela	9·8	Groveton	359 59 60·00	59·897
	22	North Mountain	48 23 06·71	07·215
	7	Ormond	86 14 04·44	04·050

TABLE OF OBSERVED AND ADJUSTED DIRECTIONS—*Concluded*

OTTAWA—GROVETON NET

Station occupied	Number of direction	Object observed	Observed direction reduced to sea-level	Seconds of adjusted direction
			° ′ ″	″
Osnabruck	10·7	Ormond	359 59 60·00	60·154
	23	Roxboro	72 11 59·72	59·943
	28	Bowesville	122 09 30·13	29·753
Lavant	15·20	Elmsley	359 59 60·00	60·000
	4	Ashton	335 11 26·20	26·609
Elizabethtown	19·20	Elmsley	359 59 60·00	60·000
	6	Montague	20 57 19·65	19·768
	8	Groveton	71 04 54·71	54·135
Elmsley	20·21	King Mountain	359 59 60·00	60·000
	6	Montagne	48 06 34·11	33·941
King Mountain	21·24	Navan	359 59 60·00	60·000
	3	Bowesville	38 52 07·86	08·835
	4	Ashton	100 18 07·75	08·084
	2	Carp	118 06 55·47	55·902
North Mountain	22·7	Ormond	359 59 60·00	59·665
	9	Dundela	65 22 53·71	53·373
	8	Groveton	130 21 43·68	41·606
	6	Montague	204 50 27·21	25·480
	5	North Gower	249 21 47·29	47·118
	3	Bowesville	288 54 31·11	30·189
Roxboro	23·26	Plantagnenet	359 59 60·00	60·000
	23·10	Osnabruck	194 53 03·19	03·056
	23·7	Ormond	260 27 43·94	43·893
Navan	24·49	Ottawa	359 59 60·00	60·000
	24·7	Ormond	279 31 51·66	51·751
	24·3	Bowesville	339 13 48·33	48·088
Bowesville	28·29	Alexandria	359 59 60·00	60·000
	28·10	Osnabruck	194 05 38·59	38·895
Ottawa	49·21	King Mountain	359 59 60·00	60·000
	49·2	Carp	305 06 38·94	38·972

ACCURACY OF THE ADJUSTMENT

Of the seventy-one directions considered in this net, thirty-seven have positive corrections and thirty-four have negative corrections. The mean of the positive corrections is $0''\cdot428$; the mean of the negative corrections is $0''\cdot584$. The maximum correction $-2''\cdot07$ to an observed direction occurs for the line North Mountain (22) to Groveton (8).

The probable error of an observed direction of weight unity is

$$r = 0\cdot6745\sqrt{\frac{\Sigma v^2}{n-q}}$$

in which Σv^2 is the sum of the squares of the corrections to directions, n is the number of observation equations and q is the number of independent unknowns.

In this case $\Sigma v^2 = 34 \cdot 263$ $n = 71$ and since there are 10 z's, 10 $\delta\varphi$'s, 10 $\delta\lambda$'s, $q = 30$, hence $r = \pm 0'' \cdot 626$.

The probable error of the corrections to the observed directions North Gower to Bowesville and Dundela to Ormond are given in table on page 59 The corrections and their probable errors are $\pm$ $0'' \cdot 729$ + $0'' \cdot 383$ and − $0'' \cdot 390 \pm 0'' \cdot 344$, respectively.

The probable error of the azimuth of the line Osnabruck to Bowesville (not included in table on page 59) is + $0'' \cdot 414$.

TABLE OF TRIANGLES—*Continued*

OTTAWA—GROVETON NET

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Carp	2	40 10 41·31	39 81	+1·50
King Mountain	21	84 55 58·30	57·87	+0·43
Ottawa	49	54 53 21·03	21·06	−0·03
		0·64	58·74	
		E = 0·64	Δ'r. closure	= +1·90
Bowesville	3	43 18 54·40	53·14	+1·26
Carp	2	57 26 19·76	18·97	+0·79
King Mountain	21	79 14 47·07	47·61	−0·54
		1·23	59·72	
		E = 1·23	Δ'r. closure	= +1·51
Bowesville	3	100 30 09·20	10·34	−1·14
King Mountain	21	38 52 08·84	07·86	+0·98
Navan	24	40 37 43·42	43·18	+0·24
		1·46	1·38	
		E = 1·45	Δ'r closure.	= +0·08
Bowesville	3	105 01 20·01	18·43	+1·58
Navan	24	42 18 13·04	13·28	−0·24
North Mountain	22	32 40 28·56	27·64	+0·92
		1·61	59·35	
		E = 1·62	Δ'r. closure	= +2·26
Bowesville	3	154 28 30·79	31·23	−0·44
North Mountain	22	11 34 29·25	30·17	−0·92
King Mountain	21	13 57 00·82	01·80	−0·98
		0·86	3·20	
		E = 0·86	Δ'r. closure	= −2·34
Ashton	4	37 36 04·00	06·08	−2·08
King Mountain	21	51 25 59·25	59·89	−0·64
Bowesville	3	80 57 58·93	58·77	+0·16
		2·18	4·74	
		E = 2·18	Δ'r. closure	= −2·56
North Gower	5	102 46 14·89	15·33	−0·44
Ashton	4	33 36 48·01	46·55	+1·46
Bowesville	3	43 36 58·35	57·96	+0·39
		1·25	59·84	
		E = 1·24	Δ'r. closure	= +1·41

TABLE OF TRIANGLES—*Continued.*

OTTAWA—GROVETON NET

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
North Gower	5	110 33 44·16	44·91	−0·75
Bowesville	3	29 53 33·51	34·50	−0·99
North Mountain	22	39 32 43·07	43·82	−0·75
		0·74	3·23	
		E = 0·75	Δ'r. closure	= −2·49
Montague	6	62 33 31·09	30·46	+0·63
Ashton	4	92 20 59·03	57·09	+1·94
Bowesville	3	25 05 31·40	31·97	−0·57
		1·52	59·52	
		E = 1·53	Δ'r. closure	= +2·00
Montague	6	79 37 10·53	09·09	+1·44
Ashton	4	58 44 11·02	10·54	+0·48
North Gower	5	41 38 39·36	36·50	+2·86
		0·91	56·13	
		E = 0·92	Δ'r. closure	= +4·78
Montague	6	17 03 39·44	38·63	+0·81
Bowesville	3	18 31 26·95	25 99	+0·96
North Gower	5	144 24 54·25	51·83	+2·42
		0·64	56·45	
		E = 0·63	Δ'r. closure	= +4·19
Montague	6	47 30 57·06	57·03	+0·03
Bowesville	3	48 25 00·46	00·49	−0·03
North Mountain	22	84 04 04·71	03·90	+0·81
		2·23	1·42	
		E = 2·22	Δ'r. closure	= +0·81
Montague	6	30 27 17·62	18·40	−0·78
North Gower	5	105 01 21·58	23·26	−1·68
North Mountain	22	44 31 21·64	20·08	+1·56
		0·84	1·74	
		E = 0·84	Δ'r. closure	= −0·90
Montague	6	166 37 01·19	01·61	−0·42
North Mountain	22	4 35 10·97	12·70	−1·73
Elmsley	20	8 47 48·06	47·89	+0·17
		0·22	2 20	
		E = 0·22	Δ'r. closure	= −1·98
Ormond	7	78 22 42·82	43·34	−0·52
North Mountain	22	71 05 29·48	28·89	+0·59
Bowesville	3	30 31 48·79	49·20	−0·41
		1·09	1·43	
		E = 1·10	Δ'r. closure	= −0·34
Ormond	7	35 11 49·62	49·66	−0·04
North Mountain	22	110 38 12·55	12·71	−0·16
North Gower	5	34 09 58·41	58·62	−0·21
		0·58	0·99	
		E = 0·57	Δ'r. closure	= −0·41

TABLE OF TRIANGLES—*Continued*

OTTAWA—GROVETON NET

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Ormond	7	124 11 16·91	18·85	−1·94
North Mountain	22	38 25 00·92	01·26	−0·34
Navan	24	17 23 43·30	43·39	−0·09
		1·13	3·50	
		E = 1·13	Δ'r. closure	= −2·37
Ormond	7	43 10 53·20	53·68	−0·48
North Gower	5	76 23 45·75	46·29	−0·54
Bowesville	3	60 25 22·31	23·70	−1·39
		1·26	3·67	
		E = 1·28	Δ'r. closure	= −2·41
Ormond	7	45 48 34·09	35·51	−1·42
Bowesville	3	74 29 31·22	29·23	+1·99
Navan	24	59 41 56·34	56·67	−0·33
		1·65	1·41	
		E = 1·65	Δ'r. closure	= +0·24
Ormond	7	75 16 41·39	38·74	+2·65
Navan	24	50 43 08·70	08·61	+0·09
Roxboro	23	54 00 12·28	12·24	+0·04
		2·37	59·59	
		E = 2·37	Δ'r. closure	= +2·78
Ormond	7	160 32 01·70	02·41	−0·71
Roxboro	23	6 29 08·94	08·99	−0·05
North Mountain	22	12 58 49·75	49·41	+0·34
		0·39	0·81	
		E = 0·40	Δ'r. closure	= −0·42
Groveton	8	41 10 12·55	11·76	+0·79
Montague	6	68 10 09·41	10·80	−1·39
North Gower	5	70 39 39·64	40·96	−1·32
		1·60	3·52	
		E = 1·59	Δ'r. closure	= −1·92
Groveton	8	67 48 25·79	26·36	−0·57
Montague	6	37 42 51·79	52·40	−0·61
North Mountain	22	74 28 43·87	43·53	+0·34
		1·45	2·29	
		E = 1·44	Δ'r. closure	= −0·84
Groveton	8	26 38 13·24	14·60	−1·36
North Gower	5	34 25 41·94	42·30	−0·36
North Mountain	22	119 00 05·51	03·61	+1·90
		0·69	0·51	
		E = 0·69	Δ'r. closure	= +0·18
Groveton	8	48 05 01·00	02·48	−1·48
North Gower	5	68 35 40·35	40·92	−0·57
Ormond	7	63 23 20·49	20·10	+0·39
		1·84	3·50	
		E = 1·84	Δ'r. closure	= −1·66

TABLE OF TRIANGLES—*Concluded*

OTTAWA—GROVETON NET.

Station	Station Number	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Groveton	8	21 26 47·77	47·88	−0·11
North Mountain	22	130 21 41·94	43·68	−1·74
Ormond	7	28 11 30·88	30·44	+0·44
		0·59	2·00	
		E = 0·58	Δ'r. closure	= −1·41
Groveton	8	159 52 27·49	25·95	+1·54
Elizabethtown	19	8 54 03·09	03·67	−0·58
North Mountain	22	11 13 29·85	27·78	+2·07
		0·43	57·40	
		E = 0·44	Δ'r. closure	= +3·03
Dundela	9	48 23 07·31	06·71	+0·60
Groveton	8	66 38 05·56	05·64	−0·08
North Mountain	22	64 58 48·23	49·97	−1·74
		1·10	2·32	
		E = 1·10	Δ'r. closure	= −1·22
Dundela	9	86 14 04·15	04·44	−0·29
Groveton	8	45 11 17·80	17·77	+0·03
Ormond	7	48 34 39·43	39·93	−0·50
		1·38	2·14	
		E = 1·38	Δ'r. closure	= −0·76
Dundela	9	37 50 56·84	57·73	−0·89
North Mountain	22	65 22 53·71	53·71	0·00
Ormond	7	76 46 10·31	10·37	−0·06
		0·86	1·81	
		E = 0·86	Δ'r. closure	= −0·95
Osnabruck	10	72 11 59·79	59·72	+0·07
Ormond	7	42 13 20·89	21·90	−1·01
Roxboro	23	65 34 40·84	40·75	+0·09
		1·52	2·37	
		E = 1·52	Δ'r. closure	= −0·85
Osnabruck	10	49 57 29·81	30·41	−0·60
Roxboro	23	62 11 52·24	52·37	−0·13
Bowesville	28	67 50 38·80	39·11	−0·31
		0·85	1·89	
		E = 0·85	Δ'r. closure	= −1·04

CONCLUDING REMARKS

The correction to each observed angle is the algebraic difference of the corrections to two directions. In the above table are shown for every triangle in the Ottawa–Groveton net the adjusted spherical angles, the observed angles, the corrections to the observed angles, the spherical excess and the triangular closure. The plus sign prefixed to the triangular closure indicates that the

sum of the observed angles is less than 180° + spherical excess of the triangle. The negative sign has, of course, the opposite meaning, that is, the sum of the three observed angles is more than 180° + spherical excess. Two values of the spherical excess are given, the first being obtained from the adjusted angles and the second from the adjusted azimuths. Slight discrepancies between these two values occur due to the rejection of the third decimal place, the maximum discrepancy amounting to 0″·02 in the triangle Ormond–North Gower–Bowesville. If the spherical excess of any triangle is required to three decimal places its value may be readily obtained from the column seconds of adjusted direction in the table on page 63.

The maximum correction 2″·86 to any angle is to the angle at North Gower between Montague and Ashton.

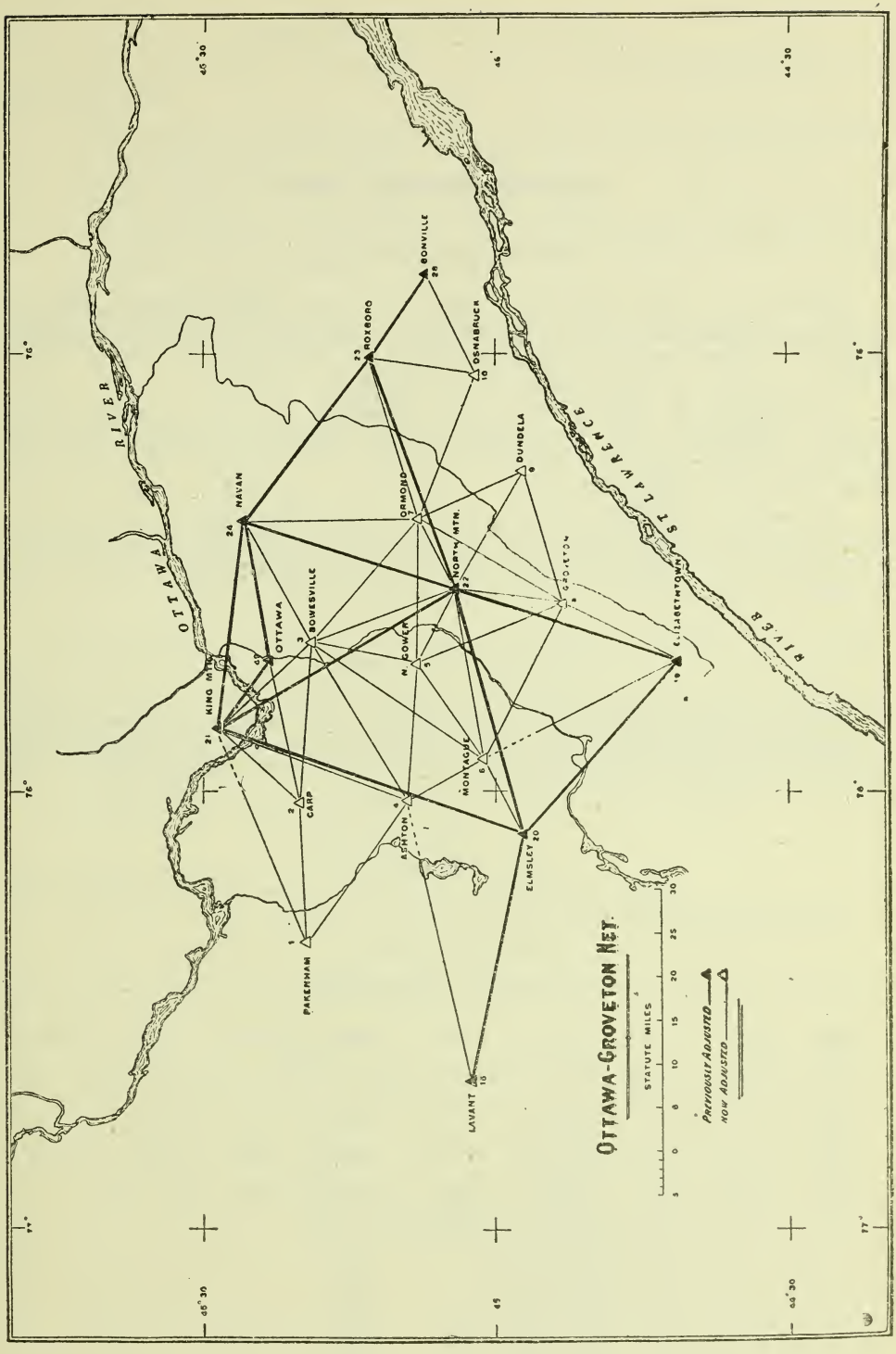
The average closing error of these thirty-two triangles is 1″·63. Of the thirty-two triangular closures thirteen are positive and nineteen negative. The mean of the positive closures is 1″·94, the mean of the negative closures is 1″·36. The maximum closing error + 4″·78 occurs in the triangle Montague–Ashton–North Gower.

In the following table are given for two lines the logarithm of the final distance, the distance in metres, the probable error of the distance and the probable error expressed as a ratio. The probable errors are those given in the table of evaluation of the unknowns on page 59, and result from a consideration of the accidental errors only. The positions of the stations and the distances of the connecting lines of the Dusable–Haldimand net which serve as a control for the Ottawa–Groveton net are considered as being without error

Line	Logarithm of Distance	Distance in Metres	Probable Error	
			of distance	expressed as a ratio
Pakenham to Carp	4·4335751	27137·83	0·17	1·159600
North Gower to Ormond	4·4069330	25523·09	0·05	1·510500

The probable errors of the final adjusted position of Bowesville and Dundela are as indicated in the following table. Station Bowesville was selected for this computation because it is directly connected with more fixed stations than any other station with the exception of Ormond and, in addition, is more strongly connected with the remaining stations than any other. Its accuracy of position as indicated by the probable errors will then most nearly represent the highest attainable accuracy in this net. Station Dundela was selected because it lies outside of the controlled area and is, relative to the inner points, poorly connected. Its probable error will therefore represent the lowest degree of accuracy attained. These values, of course, assume that no error arises from basing the adjustment on the Dusable–Haldimand net; or, in other words, that the positions and distances of basic points and lines are without error.

	Probable error in seconds		Probable error in inches	
	ϕ	λ	ϕ	λ
Bowesville	0·001	0·001	1·2	0·8
Dundela	0·002	0·004	2·4	3·4


OTTAWA RIVER
ST LAWRENCE RIVER
BONVILLE
ROXBORO
DENBRUCH
DUNDELA
NAVAN
ORMOND
NORTH MTN.
CROYDON
CLARENCETOWN
OTTAWA
BOWESVILLE
N. LOWER
KING MTN.
MONTAGUE
CAMP
ASHTON
ELMSLEY
PAKENHAM
LAVANT
OTTAWA-GROVETON NET
STATUTE MILES
PREVIOUSLY ADJUSTED
NOW ADJUSTED

IV

SCOTCH BONNET NET

Introductory Remarks

This net, see page 73 for map, called the Scotch Bonnet net on account of the great prominence of one of its stations, a lighthouse called Scotch Bonnet situated in lake Ontario, comprises that part of Ontario known as Prince Edward county, one of the oldest settled portions of Canada.

Comprising six points, which are dependent upon the primary points Murray, Hallowell, and Tyendinaga of the Dusable–Haldimand net, and covering territory which is limited in extent by the water, it therefore takes upon itself a secondary character.

As such, it establishes such points as Presqu'île lighthouse and Scotch Bonnet lighthouse, etc., which are prominent and essential signals for navigation. At the same time it will serve as a basis for tertiary surveys which will be made to define the important shore line of the county of Prince Edward.

Nature of Adjustment

The conditional adjustment was employed. The straight Gaussian method of elimination was employed, though as stated on page 10 a combination of the Doolittle method of evaluation and the point-to-point arrangement of the conditional equations, will be used in the future.

The Conditions

These were fourteen in number, and are as follows:—

CONDITION EQUATIONS

$$-2{\cdot}86v_1 - 9{\cdot}10v_2 - 5{\cdot}23v_6 + 3{\cdot}77v_7 + 1{\cdot}46v_9 - 0{\cdot}66v_{14} + 2{\cdot}73v_{15} - 2{\cdot}07v_{17} + 11{\cdot}96v_{32} + 16{\cdot}4 = 0$$

$$+1{\cdot}80v_1 - 4{\cdot}03v_2 + 2{\cdot}23v_3 + 4{\cdot}18v_7 + 0{\cdot}82\,v_9 + 3{\cdot}00v_{14} - 2{\cdot}57v_{15} - 0{\cdot}43v_{16} + 6{\cdot}30v_{28} + 6{\cdot}99\,v_{29} + 42{\cdot}1 = 0$$

$$-4{\cdot}43v_5 + 8{\cdot}20v_6 - 3{\cdot}77v_7 - 3{\cdot}55v_{10} + 1{\cdot}67v_{11} + 1{\cdot}88v_{12} + 1{\cdot}12v_{13} + 0{\cdot}65v_{14} - 1{\cdot}77v_{17} + 17{\cdot}0 = 0$$

$$-2{\cdot}28v_6 + 3{\cdot}70v_8 + 0{\cdot}52v_{22} + 2{\cdot}63v_{23} - 3{\cdot}15v_{24} - 5{\cdot}22v_{25} + 5{\cdot}29v_{26} - 0{\cdot}07v_{27} + 4{\cdot}34v_{30} - 1{\cdot}39v_{31} - 18{\cdot}1 = 0$$

$$+2{\cdot}35v_6 - 3{\cdot}77v_7 + 0{\cdot}65v_{14} + 1{\cdot}04v_{16} - 1{\cdot}69v_{17} - 6{\cdot}21v_{29} + 3{\cdot}26v_3^{0} - 20{\cdot}1 = 0$$

$$-3{\cdot}03v_1 - 1{\cdot}62v_3 + 4{\cdot}65v_4 + 4{\cdot}76v_9 - 2{\cdot}03v_{28} + 3{\cdot}20 = 0$$

$$v_1 - v_3 + v_7 - v_9 - v_{14} + v_{16} + v_{28} - v_{29} - 0{\cdot}530 = 0$$

$$v_5 - v_7 + v_{11} - v_{12} - v_{13} + v_{14} + 7{\cdot}096 = 0$$

$$v_5 - v_6 + v_{10} - v_{12} + v_{20} - v_{21} - 1{\cdot}330 = 0$$

$$v_6 - v_8 + v_{19} - v_{20} - v_{22} + v_{23} + 0{\cdot}460 = 0$$

$$v_{18} - v_{19} + v_{22} - v_{24} - v_{25} + v_{26} - 4{\cdot}840 = 0$$

$$-v_2 + v_3 + v_7 - v_{14} + v_{15} - v_{28} - 5{\cdot}290 = 0$$

$$-v_1 + v_2 + v_9 - v_{15} + v_{16} - v_{29} + 2{\cdot}280 = 0$$

$$v_8 - v_{23} + v_{24} - v_{26} + v_{27} - v_{31} + 13{\cdot}216 = 0$$

Accuracy of the Adjustment

The accuracy of the adjustment of nets is generally inferred from an examination of—

(1) the sum of v's about a point, which does not include a fixed direction.

(2) the equivalence of $[v_2]$ and $-[kl]$ where k is a correlate and l the absolute term of a conditional equation.

(3) the absolute term of the normal equations as observed and as determined by a substitution in the said normal equations of the values of the correlates. This gives what is known as the O—C test.

In our case we have—

Point	Sum of v's
Sidney	−·0001
Presqu'isle	+·0001
Scotch Bonnet	·0000
Ameliasburg (S)	+·0001
West Point	+·0001
Point Petre	·0000

This condition (1) while a little difficult to prove as holding true from the viewpoint of a conditional adjustment, is readily obtained from the co-ordinate adjustment theory (see page 18) where $(av)=0$ for a system of observational equations and where $(v)=0$ is a particular case if such observation equations have in them an unknown whose coefficient is unity, as is the case when the observations are made at a point where no fixed azimuth line already exists.

The second test (2) resulted as follows:—

$$[v^2]=84\cdot1309$$
$$-[kl]=84\cdot1328$$

while the third test (3) may be shown by the following table:—

ABSOLUTE TERMS

Observed	Evaluated
−16·4	−16·400
−42·1	−42·100
−17·0	−17·000
18·1	18·099
20·1	20·096
− 3·2	− 3·199
5·3	5·295
− 7·096	− 7·097
1·330	1·330
− 0·460	− 0·460
4·840	4·841
5·290	5·291
− 2·280	− 2·279
−13·216	−13·217

Precisions

No precisions were determined in this net outside of that of the probable error of an observation, viz:—

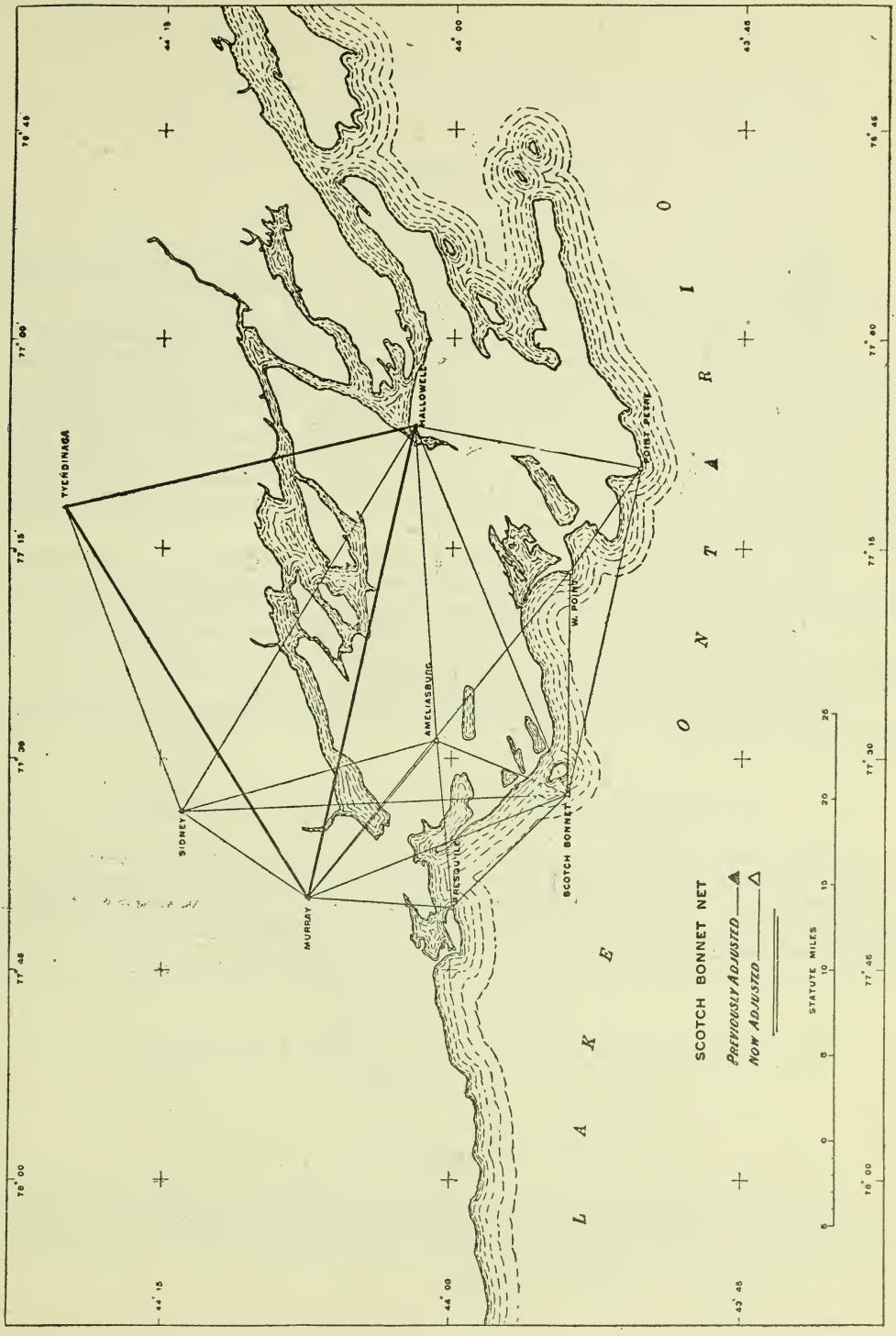
$$r = \left(\frac{v^2}{\sigma}\right)^{\frac{1}{2}} = \cdot 6745\left(\frac{84 \cdot 1309}{14}\right)^{\frac{1}{2}}$$

$= 1'' \cdot 653$ where σ is the number of conditions in the net.

It is felt that if other precisions are needed they can be determined subsequently by attaching a function, expressing the reciprocal of weight of such function, to the end of the correlate equations.

Tabulated Final Results

The tabulated results which are given on page 165 are all determined on the North American Datum. See page 11 for fuller information re such datum.


TYENDINAGA
HALLOWELL
POINT PETRE
W. POINT
SIDNEY
AMELIASBURG
PICTON
SCOTCH BONNET
MURRAY
L A K E O N T A R I O
SCOTCH BONNET NET
PREVIOUSLY ADJUSTED
NOW ADJUSTED
STATUTE MILES
0
5
10
15
20
25
77° 45
77° 30
77° 15
77° 00
76° 45
76° 00
44° 15
44° 00
43° 45

V

COTEAU BASE NET

Introduction

This geodetic net was first solved in 1911, the observing and base measurement having been completed in 1909.

The intention at that time was to base the geographic co-ordinates in this country on a Canadian datum, the initial value of which was to be based on an observed latitude (45° 30′ 36.990″) at Vankleek Hill, an observed azimuth Vankleek Hill to Rigaud (102° 38′ 10.84″) and the longitude of Royal (73° 35′ 25.197″) as determined from the United States geodetic results. Hence no complications which later arose—of basing Canadian results on the North American datum—affected the selection of a net for adjustment. Accordingly the Coteau Base net, the plan of which appears on page 111 was selected as the first net to be adjusted.

This net is of primary accuracy, but the importance of any discussion regarding it is more of historic value, as showing certain methods of adjustment which were used, rather than otherwise, as its results have been superseded by those of a larger net Dusable–Haldimand. This latter net was selected when it was decided in 1913 to base Canadian co-ordinates on the North American datum, a description of which appears on page 11.

This description of the Coteau Base net describes methods some of which have been discarded.

Preliminary Corrections to Observed Directions

All observed directions were first corrected for the altitude of the station observed on and were reduced to the direction of the geodetic line. As explained on page 8 this practice has been discontinued except for stations with very high altitudes. These corrected directions will be found on page 107 under the heading of " Observed Directions."

Spherical Excesses

The spherical excesses were computed by means of the formula,—

$$\epsilon = m\, a\, b \sin C$$

where $$m = \frac{1}{2\, RN \sin 1''}$$

For computing the spherical excesses a preliminary computation of the lengths of the triangle sides was made by adding or subtracting one-third of the difference of the sum of the three angles of the triangle from 180°, from each angle, and using plane triangle formulæ.

They are as follows:—

SPHERICAL EXCESSES

Triangle	Excess
Rigaud–Huntingdon–Royal	5·6436
Rigaud–Royal–Covey Hill	7·4030
Rigaud–Covey–Huntingdon	3·5717
Riagud–Newton–Huntingdon	1·0543
Covey Hill–E. Base–Huntingdon	2·096
Covey Hill–W. Base–Huntingdon	1·225
Covey Hill–W. Base–Rigaud	2·841
Covey Hill–E. Base–Royal	5·644
Covey Hill–Huntingdon–Royal	5·329
Rigaud–W. Base–E. Base	0·602
Newton–E. Base–Huntingdon	1·047
Huntingdon–W. Base–E. Base	0·497
Newton–Huntingdon–E. Base	1·047
E. Base–W. Base–Newton	0·539
E. Base–Newton–Rigaud	0·612

Condition Equations

The first solution of this net was by the angle method, but later this method was superseded in this survey by solution by the direction method (see page 111 for the plans which show the numbering of angles and directions n these two methods).

In order that the two methods may be compared, a summary of the condition equations (side and angle) by the two methods is shown.

The ratio of the number of side equations to the number of angle equations may be commented on. In the solution of an ordinary quadrilateral it is usual to pick out one side equation and three angle equations; in a four-sided figure with a central point the ratio is 1 to 4; in a pentagonal central point figure the ratio is 1 to 5, etc. In this base net the ratio is seen to be 7 to 12, which indicates an entanglement of lines which augurs strong adjusted values of the directions.

CONDITION EQUATIONS

Angle Adjustment

1. $0 = -16{\cdot}64\,v_5 + 3{\cdot}58\,v_6 + 3{\cdot}58\,v_7 - 0{\cdot}08\,v_8 - 0{\cdot}08\,v_9 + 7{\cdot}58\,v_{10} - 6{\cdot}49\,v_{29} + 7{\cdot}08\,v_{30} - 36{\cdot}90$
2. $0 = -5{\cdot}70\,v_1 + 8{\cdot}02\,v_2 - 2{\cdot}73\,v_9 + 7{\cdot}58\,v_{10} - 6{\cdot}49\,v_{29} + 0{\cdot}61\,v_{30} + 0{\cdot}61\,v_{31} + 8{\cdot}70$
3. $0 = +7{\cdot}98\,v_6 - 7{\cdot}49\,v_7 - 1{\cdot}50\,v_8 - 1{\cdot}50\,v_9 - 4{\cdot}71\,v_{10} - 4{\cdot}71\,v_{11} + {\cdot}044\,v_{13} + 2{\cdot}59\,v_{18} + 6{\cdot}00$
4. $0 = -3{\cdot}21\,v_{10} + 3{\cdot}37\,v_{11} - 1{\cdot}13\,v_{17} + 2{\cdot}15\,v_{18} + 3{\cdot}30\,v_{25} + 0{\cdot}76\,v_{26} + 2{\cdot}48\,v_{27} - 10{\cdot}66\,v_{28} - 4{\cdot}20$
5. $0 = +5{\cdot}70\,v_1 - 1{\cdot}98\,v_2 - 1{\cdot}98\,v_3 + 1{\cdot}08\,v_4 + 1{\cdot}08\,v_5 - 3{\cdot}58\,v_6 - 3{\cdot}58\,v_7 - 0{\cdot}08\,v_8 - 0{\cdot}08\,v_9 - 3{\cdot}15\,v_{10} - 3{\cdot}15\,v_{11} - 3{\cdot}15\,v_{12} + 2{\cdot}51\,v_{24} + 2{\cdot}51\,v_{25} - 0{\cdot}75\,v_{26} + 0{\cdot}79\,v_{27} + 0{\cdot}79\,v_{28} + 0{\cdot}79\,v_{29} - 0{\cdot}61\,v_{30} - 0{\cdot}61\,v_{31} + 2{\cdot}90$
6. $0 = +3{\cdot}01\,v_1 + 3{\cdot}01\,v_2 - 3{\cdot}36\,v_3 + 1{\cdot}44\,v_4 - 2{\cdot}73\,v_5 - 2{\cdot}73\,v_6 - 2{\cdot}73\,v_7 + 1{\cdot}49\,v_8 - 1{\cdot}58\,v_9 - 1{\cdot}58\,v_{10} + 3.06\,v_{29} + 3{\cdot}06\,v_{30} - 1{\cdot}35\,v_{31} + 2{\cdot}60$
7. $0 = +2{\cdot}49\,v_{16} - 1{\cdot}13\,v_{17} + 1{\cdot}85\,v_{21} - 3{\cdot}68\,v_{22} + 2{\cdot}54\,v_{25} - 0{\cdot}76\,v_{26} + 2{\cdot}48\,v_{27} - 3{\cdot}78\,v_{28} - 3{\cdot}78\,v_{29} - 6{\cdot}20$
8. $0 = v_1 + v_2 + v_3 + v_4 + v_5 + v_6 + v_7 + v_8 + v_9 + v_{10} + v_{29} + v_{30} + v_{31} + 0{\cdot}285$
9. $0 = v_6 + v_7 + v_8 + v_9 + v_{10} + v_{11} + v_{13} + v_{18} + v_{19} + v_{20} + 0{\cdot}416$
10. $0 = v_{16} + v_{17} + v_{21} + v_{22} + v_{25} + v_{26} + v_{27} + v_{28} + v_{29} - 1{\cdot}091$
11. $0 = v_{10} + v_{11} + v_{12} + v_{17} + v_{18} + v_{24} + v_{25} + 0{\cdot}533$
12. $0 = v_5 + v_6 + v_{20} + v_{21} + v_{28} + v_{29} + v_{30} - 0{\cdot}341$
13. $0 = v_1 + v_2 - v_5 - v_6 - v_7 - v_8 + v_{31} - 0{\cdot}572$
14. $0 = v_3 + v_4 - v_9 - v_{10} - v_{29} - v_{30} + 0{\cdot}181$
15. $0 = v_{13} + v_{14} + v_{15} + v_{16} + v_{17} + v_{18}$
16. $0 = v_{19} + v_{20} + v_{21} + v_{22} + v_{23}$
17. $0 = v_{16} - v_{22} - v_{25} + v_{28} + v_{29} + 0{\cdot}207$
18. $0 = v_7 + v_8 + v_9 - v_{18} - v_{20} + 0{\cdot}603$
19. $0 = v_6 - v_{10} - v_{11} + v_{13} - v_{19} + 0{\cdot}429$
20. $0 = v_2 + v_3 + v_4 + v_5 + v_{14} - 0{\cdot}484$
21. $0 = v_{27} + v_{26} - v_{17} - v_{21} + 0{\cdot}160$

Direction Method

1. $0 = -16{\cdot}64\,(5) + 20{\cdot}22\,(6) - 3{\cdot}58\,(7C) - 0{\cdot}08\,(8) + 7{\cdot}66\,(10) - 7{\cdot}58\,(11) - 6{\cdot}49\,(29) + 13{\cdot}57\,(30) - 7{\cdot}08\,(31) - 36{\cdot}90$
2. $0 = -5{\cdot}70\,(1) + 13{\cdot}72\,(2) - 8{\cdot}02\,(3) - 2{\cdot}73\,(9) + 10{\cdot}31\,(10) - 7{\cdot}58\,(11) - 6{\cdot}49\,(29) + 7{\cdot}10\,(30) - 0{\cdot}61\,(31R) + 8{\cdot}70$
3. $0 = +7{\cdot}98\,(6) - 15{\cdot}47\,(7) + 7{\cdot}49\,(7C) - 1{\cdot}50\,(8) - 3{\cdot}21\,(10) + 4{\cdot}71\,(12) - 2{\cdot}15\,(13) - 0{\cdot}44\,(14) + 2{\cdot}59\,(18) + 6{\cdot}00$
4. $0 = -3{\cdot}21\,(10) + 6{\cdot}58\,(11) - 3{\cdot}37\,(12) - 2{\cdot}15\,(13) - 1{\cdot}13\,(17) + 3{\cdot}28\,(18) + 3{\cdot}30\,(25) - 2{\cdot}54\,(26) - 0{\cdot}76\,(26N) + 2{\cdot}48\,(27) - 13{\cdot}14\,(28) + 10{\cdot}66\,(29) - 4{\cdot}20$
5. $0 = +5{\cdot}70\,(1) - 7{\cdot}68\,(2) + 1{\cdot}98\,(3M) + 1{\cdot}08\,(4) - 4{\cdot}66\,(6) + 3{\cdot}58\,(7C) - 0{\cdot}08\,(8) - 3{\cdot}07\,(10) + 3{\cdot}15\,(12H) + 2{\cdot}51\,(24) - 3{\cdot}26\,(26) + 0{\cdot}75\,(26N) + 0{\cdot}79\,(27) - 1{\cdot}40\,(30) + 0{\cdot}61\,(31R) + 2{\cdot}90$
6. $0 = +2{\cdot}49\,(16) - 3{\cdot}62\,(17) + 1{\cdot}13\,(18) + 1{\cdot}85\,(21) - 5{\cdot}53\,(22) + 3{\cdot}68\,(23) + 2{\cdot}54\,(25) - 3{\cdot}30\,(26) + 0{\cdot}76\,(26N) + 2{\cdot}48\,(27) - 6{\cdot}26\,(28) + 3{\cdot}78\,(30) - 6{\cdot}20$
7. $0 = +3{\cdot}01\,(1) - 6{\cdot}37\,(3) + 3{\cdot}36\,(3M) + 1{\cdot}44\,(4) - 4{\cdot}17\,(5) + 2{\cdot}73\,(7C) + 1{\cdot}49\,(8) - 3{\cdot}07\,(9) + 1{\cdot}58\,(11) + 3{\cdot}06\,(29) - 4{\cdot}41\,(31) + 1{\cdot}35\,(31R) + 2{\cdot}60$
8. $0 = (1) - (3M) + (4) - (7C) + (8) - (11) + (29) - (31R) + 0{\cdot}285$
9. $0 = (6) - (7C) + (8) - (12) - (14) + (18) + (19) - (21) + 0{\cdot}416$
10. $0 = (16) - (18) + (21) - (23) + (25) - (26N) + (27) - (30) - 1{\cdot}091$
11. $0 = (1) - (3) - (5) + (7C) - (8) + (9) + (31) - (31R) - 0{\cdot}572$
12. $0 = (3) - (3M) + (4) - (5) - (9) + (11) - (29) + (31) + 0{\cdot}181$
13. $0 = (16) - (17) - (22) + (23) - (25) + (26) + (28) - (30) + 0{\cdot}207$
14. $0 = (7) - (7C) + (8) - (10) + (13) - (18) - (20) + (21) + 0{\cdot}603$
15. $0 = (6) - (7) - (10) + (12) + (13) - (14) - (19) + (20) + 0{\cdot}429$
16. $0 = -(17) + (18) - (21) + (22) + (26) - (26N) + (27) - (28) + 0{\cdot}160$
17. $0 = (10) - (12H) - (13) + (17) + (24) - (26) + 0{\cdot}533$
18. $0 = (5) - (7) + (20) - (22) + (28) - (31) - 0{\cdot}341$
19. $0 = (2) - (3M) + (4) - (6) + (14) - (15) - 0{\cdot}484$

It will be noticed that the side and angle equations were picked out according to the plan given in Johnson's Surveying, as shown on page 9. This plan, while giving ideally the best results, will not be continued in the future, on account of the extra labour involved, the increase in accuracy being small.

The order of arrangement of the condition equations is such that the sum of the squares of the coefficients of the equations are in decreasing order of magnitude from first to last. This is equivalent to saying that, in the normal equations, the diagonal coefficients decrease in magnitude from left to right. This method of arrangement is not used at present as it entails a larger amount of work than the slight gain in accuracy warranted. See page 10 for a discussion of the order of arrangement of condition equations.

CORRELATE EQUATIONS AND EQUATIONS

The correlate equations for the direction

		K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}
(1)	=	.....	− 5·70	.....	.....	+ 5·70	.....	+ 3·01	+1	.....	.....	+1	.....
(2)	=	.....	+13·72	.....	.....	− 7·68	.....	.....	.....	.....	.....	.....	.....
(3)	=	.....	− 8·02	.....	.....	.....	.....	− 6·37	.....	.....	.....	−1	+1
(3M)	=	.....	.....	.....	.....	+ 1·98	.....	+ 3·36	−1	.....	.....	.....	−1
(4)	=	.....	.....	.....	.....	+ 1·08	.....	+ 1·44	+1	.....	.....	.....	+1
(5)	=	−16·64	.....	.....	.....	.....	.....	− 4·17	.....	.....	.....	−1	−1
(6)	=	+20·22	.....	+ 7·98	.....	− 4·66	.....	.....	.....	+1	.....	.....	.....
(7)	=	.....	.....	−15·47	.....	.....	.....	.....	.....	.....	.....	.....	.....
(7C)	=	− 3·58	.....	+ 7·49	.....	+ 3·58	.....	+ 2·73	−1	−1	.....	+1	.....
(8)	=	− 0·08	.....	− 1·50	.....	− 0·08	.....	+ 1·49	+1	+1	.....	−1	.....
(9)	=	.....	− 2·73	.....	.....	.....	.....	− 3·07	.....	.....	.....	+1	−1
(10)	=	+ 7·66	+10·31	− 3·21	− 3·21	− 3·07	.....	.....	.....	.....	.....	.....	.....
(11)	=	− 7·58	− 7·58	.....	+ 6·58	.....	.....	+ 1·58	−1	.....	.....	.....	+1
(12)	=	.....	.....	+ 4·71	− 3·37	.....	.....	.....	.....	−1	.....	.....	.....
(12H)	=	.....	.....	.....	.....	+ 3·15	.....	.....	.....	.....	.....	.....	.....
(13)	=	.....	.....	− 2·15	− 2·15	.....	.....	.....	.....	.....	.....	.....	.....
(14)	=	.....	.....	− 0·44	.....	.....	.....	.....	.....	−1	.....	.....	.....
(15)	=	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(16)	=	.....	.....	.....	.....	.....	+ 2·49	.....	.....	.....	+1	.....	.....
(17)	=	.....	.....	.....	− 1·13	.....	− 3·62	.....	.....	.....	.....	.....	.....
(18)	=	.....	.....	+ 2·59	+ 3·28	.....	+ 1·13	.....	.....	+1	−1	.....	.....
(19)	=	.....	.....	.....	.....	.....	.....	.....	.....	+1	.....	.....	.....
(20)	=	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(21)	=	.....	.....	.....	.....	.....	+ 1·85	.....	.....	−1	+1	.....	.....
(22)	=	.....	.....	.....	.....	.....	− 5·53	.....	.....	.....	.....	.....	.....
(23)	=	.....	.....	.....	.....	.....	+ 3·68	.....	.....	.....	−1	.....	.....
(24)	=	.....	.....	.....	.....	+ 2·51	.....	.....	.....	.....	.....	.....	.....
(25)	=	.....	.....	.....	+ 3·30	.....	+ 2·54	.....	.....	.....	+1	.....	.....
(26)	=	.....	.....	.....	− 2·54	− 3·26	− 3·30	.....	.....	.....	.....	.....	.....
(26N)	=	.....	.....	.....	− 0·76	+ 0·75	+ 0·76	.....	.....	.....	−1	.....	.....
(27)	=	.....	.....	.....	+ 2·48	+ 0·79	+ 2·48	.....	.....	.....	+1	.....	.....
(28)	=	.....	.....	.....	−13·14	.....	− 6·26	.....	.....	.....	.....	.....	.....
(29)	=	− 6·49	− 6·49	.....	+10·66	.....	.....	+ 3·06	+1	.....	.....	.....	−1
(30)	=	+13·57	+ 7·10	.....	.....	− 1·40	+ 3·78	.....	.....	.....	−1	.....	.....
(31)	=	− 7·08	.....	.....	.....	.....	.....	− 4·41	.....	.....	.....	+1	+1
(31R)	=	.....	− 0·61	.....	.....	+ 0·61	.....	+ 1·35	−1	.....	.....	−1	.....

FOR THE PROBABLE ERROR OF SIDES

method of solution are shown below:—

K_{13}	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	Side 1	Side 2	Side 3	Side 4	Side 5	Check
												+ 5·01
						+1		− 1·98	− 1·98			+ 3·08
												−14·39
						−1		+ 1·98	+ 1·98			+ 6·30
						+1		+ 1·08				+ 6·60
					+1							−21·81
		+1				−1		− 4·66	− 3·58	− 3·58		+12·72
	+1	−1			−1							−16·47
	−1							+ 3·58	+ 3·58	+ 3·58		+18·96
	+1							− 0·08	− 0·08			+ 1·67
												− 5·80
	−1	−1		+1				− 3·13	− 3·13	− 3·21	− 3·15	− 5·14
												− 7·00
		+1						+ 3·21	+ 3·21	+ 3·21		+10·97
				−1							+ 3·15	+ 5·30
	+1	+1		−1						+ 1·35	+ 0·61	− 1·34
		−1				+1			+ 0·75	− 1·35		− 2·04
						−1		+ 0·15	− 0·75			− 1·60
+1							+ 2·48	− 0·15				+ 6·82
−1			−1	+1			− 2·48				− 0·61	− 8·84
	−1		+1									+ 7·00
		−1						− 0·46	− 0·46	− 0·46		− 1·38
	−1	+1			+1							+ 1·00
	+1		−1				+ 0·42	+ 0·46	+ 0·46	+ 0·46	+ 0·42	+ 4·07
−1			+1		−1							− 6·53
+1							− 0·42				− 0·42	+ 2·84
				+1								+ 3·51
−1							− 2·54				− 2·54	+ 0·76
+1			+1	−1			+ 2·54				+ 2·54	− 3·02
			−1									− 1·25
			+1				− 0·79					+ 6·96
+1			−1		+1							−18·40
												+ 0·74
−1							+ 0·79	− 0·61				+21·23
					−1							−10·49
								+ 0·61				− 0·04

Formation of Equation for Reciprocal of Weights

It will be seen that the equations for finding the reciprocal of weights and hence the probable error of the lengths of the exterior sides of the figure are placed in vertical columns at the right hand side of the correlate equations. The method of forming such equations and the method of computing the probable errors of the sides is shown below.

FORMATION OF EQUATIONS FOR WEIGHTS OF EXTERIOR SIDES

Side 1 = Newton – Rigaud

$$S_1 = b\,\frac{\sin(21-23)\sin(16-17)}{\sin(25-26)\sin(27-30)}$$

+Angle	C.D.*	−Angle	C.D.*
21 − 23 = 78° 36′ 18·82″.....	0·42	25 − 26 = 39° 37′ 40·35″.....	2·54
16 − 17 = 40° 17′ 30·45″.....	2·48	27 − 30 = 69° 26′ 27·59″.....	0·79

$$\therefore d\log S_1 = 2\cdot48\,(16) - 2\cdot48\,(17) + 0\cdot42\,(21) - 0\cdot42\,(23) - 2\cdot54\,(25) + 2\cdot54\,(26) - 0\cdot79\,(27) + 0\cdot79\,(30)$$

Side 2 = Rigaud – Royal

$$S_2 = b\,\frac{\sin(19-21)\sin(8-10)\sin(4-6)\sin(15-16)}{\sin(10-12)\sin(6-7C)\sin(2-3M)\sin(30-31R)}$$

+Angle	C.D.*	−Angle	C.D.*
19 − 21 = 102° 17′ 10·40″.....	−0·46	10 − 12 = 33° 15′ 17·28″.....	3·21
8 − 10 = 92° 15′ 22·55″.....	−0·08	6 − 7C = 30° 29′ 06·45″.....	3·58
4 − 6 = 62° 49′ 45·87″.....	1·08	2 − 3M = 46° 46′ 41·84″.....	1·98
15 − 16 = 85° 49′ 35·10″.....	0·15	30 − 31R = 73° 54′ 06·38″.....	0·61

$$\therefore d\log S_2 = -1\cdot98\,(2) + 1\cdot98\,(3M) + 1\cdot08\,(4) - 4\cdot66\,(6) + 3\cdot58\,(7C) - 0\cdot08\,(8) - 3\cdot13\,(10) + 3\cdot21\,(12) + 0\cdot15\,(15) - 0\cdot15\,(16) - 0\cdot46\,(19) + 0\cdot46\,(21) - 0\cdot61\,(30) + 0\cdot61\,(31R)$$

Side 3 = Royal – Covey

$$S_3 = b\,\frac{\sin(19-21)\sin(8-10)\sin(14-15)}{\sin(10-12)\sin(6-7C)\sin(2-3M)}$$

+Angle	C.D.*	−Angle	C.D.*
19 − 21 = 102° 17′ 10·40″.....	−0·46	10 − 12 = 33° 15′ 17·28″.....	3·21
8 − 10 = 92° 15′ 22·55″.....	−0·08	6 − 7C = 30° 29′ 06·45″.....	3·58
14 − 15 = 70° 23′ 47·44″.....	0·75	2 − 3M = 46° 46′ 41·84″.....	1·98

$$\therefore d\log S_3 = -1\cdot98\,(2) + 1\cdot98\,(3M) - 3\cdot58\,(6) + 3\cdot58\,(7C) - 0\cdot08\,(8) - 3\cdot13\,(10) + 0\cdot75\,(14) - 0\cdot75\,(15) - 0\cdot46\,(19) + 0\cdot46\,(21) + 3\cdot21\,(12)$$

*In units of 6th decimal place.

SIDE 4 = COVEY — HUNTINGDON

$$S_4 = b \frac{\sin (19-21) \sin (13-14)}{\sin (10-12) \sin (6-7C)}$$

+Angle	C.D.*	−Angle	C.D.*
19 − 21 = 102° 17′ 10·40″.....	−0·46	10 − 12 = 33° 15′ 17·28″.....	3·21
13 − 14 = 57° 15′ 33·89″.....	1·35	6 − 7C = 30° 29′ 06·45″.....	3·58

$$d \log S_4 = 3{\cdot}58\,(6) + 3{\cdot}58\,(7C) - 3{\cdot}21\,(10) + 3{\cdot}21\,(12) + 1{\cdot}35\,(13) - 1{\cdot}35\,(14) - 0{\cdot}46\,(19) + 0{\cdot}46\,(21)$$

SIDE 5 = HUNTINGDON — NEWTON

$$S_5 = b \frac{\sin (21-23) \sin (17-13)}{\sin (25-26) \sin (10-12H)}$$

+Angle	C.D.*	−Angle	C.D.*
21 − 23 = 78° 36′ 18·82″.....	0·42	25 − 26 = 39°−37′ 40·35″.....	2·54
17 − 13 = 106° 13′ 33·10″.....	−0·61	10 − 12H = 33°−43′−05·32″.....	3·15

$$d \log S_5 = -3{\cdot}15\,(10) + 3{\cdot}15\,(12H) + 0{\cdot}61\,(13) - 0{\cdot}61\,(17) + 0{\cdot}42\,(21) - 0{\cdot}42\,(23) - 2{\cdot}54\,(25) + 2{\cdot}54\,(26)$$

*In units of 6th decimal place.

NORMAL EQUATIONS AND SOLUTION

The normal equations for the direction method of solution, also the solution by the method of substitution are next shown. This table also shows the first step of the elimination of K_1, the original normal equations being seen in the lines 2, 3, 5, 7, 9, etc.

The terms below the diagonals have been omitted, the terms to the left of each diagonal term being respectively the same as those above that diagonal.

K_1	K_2	K	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}
K 1=	− 0·251949	− 0·100884	+ 0·131657	+ 0·137065	− 0·047013	− 0·053968	− 0·004207	− 0·021740	+ 0·012437	−0·005554	− 0·007763	+ 0·012437	+ 0·003813
1091·0842	+274·8981	+110·0728	−143·6484	−149·5494	+ 51·2946	+ 58·8832	+ 4·59	+ 23·72	− 13·57	+ 6·06	+ 8·47	− 13·57	− 4·16
	+549·1564	− 33·0951	−152·1549	−179·8234	+ 26·8380	+ 9·6522	− 4·00	0	− 7·10	+ 0·20	− 6·38	− 7·10	− 10·31
	− 69·2603	− 27·73282	+ 36·19226	+ 37·67891	− 12·9237	− 14·83570	− 1·15650	− 5·97628	+ 3·41891	− 1·52678	− 2·13403	+ 3·41891	+ 1·04819
		+405·3638	+ 7·5491	− 0·3979	+ 2·9267	+ 18·2127	− 8·99	− 2·69	− 2·59	+ 8·99	0	0	− 25·99
		− 11·10458	+ 14·49185	+ 15·08713	− 5·17485	− 5·94041	− 0·46308	− 2·39298	+ 1·36898	− 0·61134	− 0·85450	+ 1·36898	+ 0·41971
			+391·9805	+ 19·5243	+112·3902	+ 43·0160	+ 4·08	+ 6·65	+ 3·26	0	− 4·08	− 17·85	− 2·22
			− 18·91232	− 19·68917	+ 6·75334	+ 7·75242	+ 0·60433	+ 3·12292	− 1·78656	+ 0·79782	+ 1·11514	− 1·78656	− 0·54773
				+170·8914	+ 7·9952	+ 35·8427	+ 0·53	− 8·32	+ 1·44	+ 8·75	− 0·90	− 1·86	− 0·59
				− 20·49799	+ 7·03077	+ 8·07088	+ 0·62915	+ 3·25120	− 1·85995	+ 0·83060	+ 1·16095	− 1·85995	− 0·57023
					+145·6728	0	0	− 0·72	+ 0·01	0	0	− 0·56	+ 0·72
					− 2·41151	− 2·76827	− 0·21580	− 1·11514	+ 0·63795	− 0·28489	− 0·39820	+ 0·63795	+ 0·19559
						+132·6176	− 0·02	− 1·24	0	+ 5·96	− 6·94	0	− 1·24
						− 3·17781	− 0·24772	− 1·28012	+ 0·73233	− 0·32704	− 0·45711	+ 0·73233	+ 0·22452
							+ 8·00	+ 2·00	0	0	0	0	+ 2·00
							− 0·01931	− ·09979	+ 0·05709	− 0·02549	− 0·03563	+ 0·05709	+ 0·01750
								+ 8·00	− 2·00	− 2·00	0	0	0
								− 0·51567	+ 0·29501	− 0·13174	− 0·18414	+ 0·29501	+ 0·09044
									+ 8·00	0	0	0	+ 2·00
									− 0·16877	+ 0·07537	− 0·10534	− 0·16877	− 0·05174
										+ 8·00	0	0	− 2·00
										− 0·03366	− 0·04704	+ 0·07537	+ 0·02311
											+ 8·00	0	0
											− 0·06575	+ 0·10534	+ 0·03230
												+ 8·00	0
												− 0·16877	− 0·05174
													+ 8·00
													− 0·01586

K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	Abs Term	Side 1	Side 2	Side 3	Side 4	Side 5	Formation Check	Check
− 0·011511	0	− 0·007021	+ 0·008762	+ 0·018532	+ 0·0338196	− 0·009825	+ 0·1276608	+ 0·1000596	+ 0·100627	+ 0·022115		− 0·8124503
+12·56	0	+ 7·66	− 9·56	− 20·22	− 36·90	+ 10·7203	−139·2887	−109·1734	−109·7926	− 24·1290	+923·3517	+886·4517
−10·31	0	+ 10·31	0	+ 13·72	+ 8·70	+ 5·6090	− 64·1390	− 59·4359	− 33·0951	− 32·4765	+290·9638	+299·6638
− 3·16435	0	− 1·93006	+ 2·40866	+ 5·09441	+ 9·29694	− 2·70087	+ 35·09371	+ 27·50619	+ 27·66217	+ 6·07937		−223·34104
+29·66	+ 2·59	− 1·06	+ 15·47	− 8·42	+ 6·00	0	+ 14·9138	+ 23·2022	+ 21·3605	+ 8·8000	+585·8786	+591·8786
− 1·26705	0	− 0·77282	+ 0·96446	+ 2·03987	+ 3·72262	− 1·08147	+ 14·05198	+ 11·01384	+ 11·07630	+ 2·43426		− 89·42868
− 2·31	+ 18·25	+ 0·35	− 13·14	0	− 4·20	− 13·9904	− 0·7704	− 0·7704	− 3·4161	− 5·3443	+247·3547	+243·1547
+ 1·65354	0	+ 1·00856	− 1·25865	− 2·66209	− 4·85813	+ 1·41135	− 18·33827	− 14·37340	− 14·45491	− 3·17678		+116·70719
− 1·59	− 3·22	− 0·45	0	− 3·92	+ 2·90	− 10·0105	+ 65·6668	+ 58·2415	+ 39·3539	+ 11·3126	+ 58·9172	+ 61·8172
+ 1·72146	0	+ 1·05000	− 1·31035	− 2·77145	− 5·05770	+ 1·46932	− 19·09160	− 14·96385	− 15·04871	− 3·30728		+121·50145
0	+ 2·05	− 0·32	− 0·73	0	− 6·20	+ 0·5776	− 1·8283	+ 0·8510	+ 0·8510	− 13·3940	+334·6248	+328·4248
− 0·59045	0	− 0·36014	+ 0·44944	+ 0·95059	+ 1·73476	− 0·50397	+ 6·54831	+ 5·13252	+ 5·16162	+ 1·13438		− 41·67431
0	0	0	+ 0·24	− 1·92	+ 2·60	0	+ 18·6857	+ 16·3070	+ 9·7734	0	+337·8305	+340·4305
− 0·67780	0	− 0·41342	+ 0·51593	+ 1·09122	+ 1·19141	− 0·57853	+ 7·51708	+ 5·89183	+ 5·92524	+ 1·30220		− 47·83967
0	0	0	0	+ 2·00	+ 0·285	0	− 5·17	− 5·64	− 3·58	0	− 4·20	− 3·9150
− 0·05284	0	− 0·03223	+ 0·04022	+ 0·08506	+ 0·15523	− 0·04510	+ 0·58596	+ 0·45927	+ 0·46188	+ 0·10151		− 3·72915
0	+ 2·00	0	0	− 2·00	+ 0·416	− 0·42	− 12·45	− 12·12	− 9·94	− 0·42	− 11·95	− 11·5340
− 0·27304	0	− 0·16654	+ 0·20783	+ 0·43958	+ 0·80220	− 0·23305	+ 3·02811	+ 2·37341	+ 2·38687	+ 0·52457		− 19·27132
0	0	0	0	0	− 1·091	− 0·80	+ 0·92	+ 0·46	+ 0·46	− 1·70	− 11·21	− 12·3010
+ 0·15620	0	+ 0·09527	− 0·11890	− 0·25148	− 0·45893	+ 0·13333	− 1·73236	− 1·35781	− 1·36551	− 0·30010		+ 11·02495
0	0	0	− 2·00	0	− 0·572	0	+ 3·05	+ 3·66	+ 3·58	0	+ 42·25	+ 41·6780
− 0·06976	0	− 0·04255	+ 0·05310	+ 0·11230	+ 0·20495	− 0·05954	+ 0·77362	+ 0·60636	+ 0·60980	+ 0·13402		− 4·92345
0	0	0	− 2·00	+ 2·00	+ 0·181	0	− 0·90	− 1·98	0	0	− 4·71	− 4·5290
− 0·09750	0	− 0·05947	+ 0·07421	+ 0·15697	+ 0·28645	− 0·08322	+ 1·08129	+ 0·84750	+ 0·85231	+ 0·18731		− 6·88145
0	0	− 2·00	+ 2·00	0	+ 0·207	+ 8·83	+ 0·46	0	0	+ 5·27	− 18·38	− 18·1730
+ 0·15620	0	+ 0·09527	− 0·11890	− 0·25148	− 0·45893	+ 0·13333	− 1·73236	− 1·35781	− 1·36551	− 0·30010		+ 11·02495
0	− 2·00	− 2·00	− 2·00	0	+ 0·603	+ 0·42	− 0·07	− 0·07	+ 0·144	+ 4·18	− 33·89	− 33·2870
+ 0·04789	0	+ 0·02921	− 0·03645	− 0·07709	− 0·14069	+ 0·04087	− 0·53107	− 0·4625	− 0·41861	− 0·09200		+ 3·37979
+ 8·00	0	− 2·00	+ 2·00	− 2·00	+ 0·429	0	+ 2·14	+ 2·47	+ 6·00	+ 0·376	+ 48·38	+ 48·8090
− 0·14458	0	− 0·08818	+ 0·11005	+ 0·23276	+ 0·42477	− 0·12340	+ 1·60342	+ 1·25675	+ 1·26388	+ 0·27776		− 10·20438
	+ 8·00	− 2·00	− 2·00	0	+ 0·160	+ 3·81	− 0·46	− 0·46	− 0·46	+ 2·73	+ 28·83	+ 28·9900
							0					
		+ 6·00	0	0	+ 0·0533	− 5·02	− 3·13	− 3·13	− 4·56	− 10·06	− 11·41	− 10·8770
		− 0·05378	+ 0·06712	+ 0·14196	+ 0·25906	− 0·07526	+ 0·97788	+ 0·76646	+ 0·77080	+ 0·16940		− 6·22337
			+ 6·00	0	− 0·341	0	0	0	0	0	− 5·72	− 6·0610
			− 0·08376	− 0·17717	− 0·32332	+ 0·09393	− 1·22044	− 0·95657	− 0·96199	− 0 21142		+ 7·76702
				+ 6·00	− 0·484	0	+ 1·63	+ 1·12	+ 2·23	0	− 9·78	− 10·2640
				− 0·37472	− 0·68383	+ 0·19866	− 2·58130	− 2·02321	− 2·03468	− 0·44717		+ 16·42775
						26·8050	64·8590	55·1292	50·3092	33·8452		
						− 0·10533	− 17·78171	− 10·92385	− 11·04810	− 0·53361		

SOLUTION OF NORMAL EQUATIONS

ELIMINATION.—1.

K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}
$K_2=$	+ 0·126723	+ 0·2416411	+ 0·2961985	− 0·0289942	+ 0·0108013	+ 0·0107450	+ 0·0124533	+ 0·0076706	+ 0·0027647	+ 0·0177414	+ 0·0076706	+ 0·0192996
+479·89610	− 60·82792	−115·96264	−142·14449	+ 13·91422	− 5·18350	− 5·15650	− 5·97628	− 3·68109	− 1·32678	− 8·51403	− 3·68109	− 9·26181
	+394·25922	+ 22·04095	+ 14·68923	− 2·24815	+ 12·27229	− 9·45308	− 5·08298	− 1·22102	+ 8·37866	− 0·85450	+ 1·36898	− 25·57029
	− 7·71008	− 14·69853	− 18·01714	+ 1·76366	− 0·65702	− 0·65360	− 0·75757	− 0·46659	− 0·16817	− 1·07917	− 0·46659	− 1·77395
		+373·06768	− 0·16487	+119·14354	+ 50·76842	+ 0·68433	+ 9·77292	+ 1·47344	+ 0·79782	− 2·96486	− 19·63656	− 2·78773
		− 28·02134	− 34·34796	+ 3·36224	− 1·25255	− 1·24602	− 1·44412	− 0·88950	− 0·32060	− 2·05734	− 0·88950	− 2·23803
			+150·39341	+ 15·02597	+ 43·91358	+ 1·15915	− 5·06880	− 0·41995	+ 9·58060	+ 0·26095	− 3·71995	− 1·16023
			− 42·10298	+ 4·12137	− 1·53535	− 1·52734	− 1·77017	− 1·09033	− 0·39299	− 2·52184	− 1·09033	− 2·74333
				+143·26129	− 2·76827	− 0·21580	− 1·83514	+ 0·64795	− 0·28489	− 0·39820	+ 0·07795	+ 0·91559
				− 0·40343	+ 0·15029	+ 0·14951	+ 0·17328	+ 0·10673	+ 0·03847	+ 0·24686	+ 0·10673	+ 0·26854
					129·43979	− 0·26772	− 2·52012	+ 0·73233	+ 5·63296	− 7·39711	+ 0·73233	− 1·01548
					− 0·05599	− 0·05570	− 0·06455	− 0·03976	− 0·01433	− 0·08196	− 0·03976	− 0·10004
						7·98069	+ 1·90021	+ 0·05709	− 0·02549	− 0·03563	+ 0·05709	+ 2·01750
						− 0·05541	− 0·06422	− 0·03955	− 0·01426	− 0·09148	− 0·03955	− 0·09952
							7·48433	− 1·70499	− 2·13174	− 0·18414	+ 0·29501	+ 0·09044
							− 0·07442	− 0·04584	− 0·01652	− 0·10603	− 0·04584	− 0·11534
								+ 7·83123	+ 0·07537	+ 0·10534	− 0·16877	+ 1·94826
								− 0·02824	− 0·01018	− 0·06531	− 0·02824	− 0·07104
									7·96634	− 0·04704	+ 0·07537	− 1·97699
									− 0·00367	− 0·02354	− 0·01018	− 0·02561
										7·93425	+ 0·10534	+ 0·03230
										− 0·15105	− 0·06531	− 0·16432
											7·83123	− 0·05174
											− 0·02824	− 0·07104
												+ 7·98414
												− 0·17875

K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	Absolute Term.	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-* Check.
+ 0·0280776	0	− 0·0174620	− 0·0050191	− 0·0392052	− 0·0375017	− 0·0060599	+ 0·0605241	+ 0·0665346	+ 0·0113211	+ 0·0550059	− 0·1590402	
−13·47435	0	+ 8·37994	+ 2·40866	+ 18·81441	+ 17·99694	+ 2·90813	− 29·04529	− 31·92971	− 5·43293	− 26·39713	+ 76·32276	+ 1
+28·39295	+ 2·59	− 1·83282	+ 16·43446	− 6·38013	+ 9·72262	− 1·08147	+ 28·96578	+ 34·21604	+ 32·43680	+ 11·23426	+502·44992	− 1
− 1·70890	0	+ 1·06218	+ 0·30530	+ 2·38477	+ 2·28115	+ 0·36861	− 3·68156	+ 4·04716	− 0·68864	− 3·34589	+ 9·67408	
− 0·65646	+ 18·25	+ 1·35856	− 14·39865	− 2·66209	− 9·05813	− 12·57915	− 19·10867	− 15·14380	− 17·87101	− 8·52108	+359·86199	+ 1·5
− 3·25595	0	+ 2·02494	+ 0·58203	+ 4·54634	+ 4·34880	+ 0·70272	− 7·01853	− 7·71553	− 1·31282	− 6·37863	+ 18·44272	
+ 0·13146	− 3·22	+ 0·60000	− 1·31035	− 6·69145	− 2·15770	− 8·54118	+ 46·57520	+ 43·27765	+ 24·30519	+ 8·00532	+183·31865	+ 1·1
− 3·99109	0	+ 7·48213	+ 0·71343	+ 5·57280	+ 5·33066	+ 0·86138	− 8·60317	− 9·45753	− 1·60923	− 7·81879	+ 22·60669	
− 0·59045	+ 2·05	− 0·68014	− 0·78056	+ 0·95059	− 4·46524	+ 0·07363	+ 4·72601	+ 5·98352	+ 6·01262	− 12·25962	+286·75049	− 0·7
+ 0·39068	0	− 0·24297	− 0·06984	− 0·54551	− 0·52181	− 0·08432	+ 0·84215	+ 0·92578	+ 0·15752	+ 0·76536	− 2·21292	
− 0·67780	0	− 0·41342	+ 0·75593	− 0·82878	+ 4·59141	− 0·57853	+ 26·20278	+ 22·19883	+ 15·69864	+ 1·30220	+292·59083	− 0·7
− 0·14554	0	+ 0·09051	+ 0·02602	+ 0·20322	+ 0·19439	+ 0·03141	− 0·31373	− 0·34488	− 0·05868	− 0·28512	+ 0·82438	
− 0·05284	0	− 0·03223	+ 0·04022	+ 2·08506	+ 0·4402	− 0·04510	− 4·58404	− 5·18073	− 3·11812	+ 0·10151	− 7·64415	− 0·4
− 0·14478	0	+ 0·09004	+ 0·02588	+ 0·20216	+ 0·19338	+ 0·03125	− 0·31209	− 0·34309	− 0·05838	− 0·28364	+ 0·82009	
− 0·27304	+ 2·00	− 0·16654	+ 0·20783	− 1·56042	+ 1·21820	− 0·65305	− 9·42	− 9·74659	− 7·55313	+ 0·10457	− 30·80532	− 0·2
− 0·16780	0	+ 0·10436	+ 0·03000	+ 0·23430	+ 0·22412	+ 0·03622	− 0·36171	− 0·39763	− 0·06766	− 0·32873	+ 0·95047	
+ 0·15620	0	+ 0·09527	− 0·11890	− 0·25148	− 1·54993	− 0·66667	− 0·81236	− 0·89781	− 0·90551	− 2·00010	− 1·27605	− 0·5
− 0·10336	0	+ 0·06428	+ 0·01848	+ 0·14432	+ 0·13805	+ 0·02231	− 0·22279	− 0·24492	− 0·04167	− 0·20248	+ 0·58544	
− 0·06916	0	− 0·04255	− 1·94690	+ 0·11230	− 0·36705	− 0·05954	+ 3·82362	+ 4·26636	+ 4·18980	+ 0·13402	+ 36·75455	+ 0·4
− 0·03725	0	+ 0·02317	+ 0·00666	+ 0·05202	+ 0·04876	+ 0·00804	− 0·08030	− 0·08828	− 0·01502	− 0·07298	+ 0·21101	
− 0·09750	0	− 0·05947	− 6·92579	+ 2·15697	+ 0·46745	− 0·08322	+ 0·18129	− 1·13250	+ 0·85231	+ 0·18731	− 11·41045	− 0·3
− 0·23905	0	+ 0·14867	+ 0·04273	+ 0·33379	+ 0·31929	+ 0·05159	− 0·51530	− 0·56648	− 0·09639	− 0·46832	+ 1·35407	
+ 0·15620	0	− 1·90413	+ 0·88110	− 0·25148	− 0·25193	+ 8·96333	− 1·27236	− 1·35781	− 1·36551	+ 4·96990	− 7·14805	− 0·5
− 0·10336	0	+ 0·06428	+ 0·01848	+ 0·14432	+ 0·13805	+ 0·02231	− 0·22279	− 0·24492	− 0·04167	− 0·20248	+ 0·58544	
+ 0·04789	− 2·0000	− 1·97079	− 2·03645	− 0·07709	+ 0·46231	+ 0·46087	− 0·60117	+ 0·48625	+ 1·02139	+ 4·08800	− 29·90721	+ 0·8
− 0·26005	0	+ 0·16173	+ 0·04649	+ 0·36311	+ 0·34733	+ 0·05613	− 0·56056	− 0·61623	− 0·10485	− 0·50945	+ 1·47300	
+ 7·85542	0	− 2·08818	+ 2·11005	− 1·76724	+ 0·85377	− 0·12340	+ 3·74342	+ 3·72675	+ 7·26388	+ 4·03776	+ 38·60462	+ 1·1
− 0·37833	0	+ 0·23529	+ 0·06763	+ 0·52826	+ 0·50531	+ 0·08165	− 0·81552	− 0·89651	− 0·15254	− 0·74117	2·14296	
	+ 8·00	− 2·00	− 2·00		+ 0·1600	+ 3·81	− 0·46	− 0·46	− 0·46	+ 2·73	+ 28·9900	0
		+ 5·94622	+ 0·06712	+ 0·14196	+ 0·79216	− 5·09526	− 2·15212	− 2·36354	− 3·78920	− 9·89060	− 17·10037	− 0·9
		− 0·14633	− 0·04206	− 0·32854	− 0·31426	− 0·05078	+ 0·50719	+ 0·55756	+ 0·09487	+ 0·46095	− 1·33275	
			+ 5·91624	− 0·17717	− 0·66432	+ 0·09393	− 1·22044	− 0·95657	− 0·96199	− 0·21142	+ 1·70602	+ 0·1
			− 0·01209	− 0·09443	− 0·09033	− 0·01460	+ 0·14578	+ 0·16026	+ 0·02727	+ 0·13249	− 0·38309	
				+ 5·62528	− 1·16783	+ 0·19866	− 0·95130	− 0·90321	+ 0·19532	− 0·44717	+ 6·16375	− 0·4
				− 0·73762	− 0·70557	− 0·11401	+ 1·13873	+ 1·25181	+ 0·21300	+ 1·03490	− 2·99225	
						+ 26·69967	+ 47·07729	+ 44·20535	+ 39·26110	+ 33·31159		
						− 0·01762	− 1·75794	− 2·12443	− 0·06151	− 1·45200		

* In units of the 4th decimal place.

K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}
K_3 =	− 0·0189948	+ 0·0086093	+ 0·0012534	− 0·0300486	+ 0·0261459	+ 0·0151093	+ 0·0043658	− 0·0212405	+ 0·0050024	− 0·0023345	+ 0·0691872	− ·0690340
+386·54914	+ 7·34242	− 3·32791	− 0·48449	+ 11·61527	− 10·10668	− 5·84049	− 1·68761	+ 8·21049	− 1·93367	+ 0·90239	− 26·74424	+ 26·68505
	+345·04634	− 34·51283	+122·50578	+ 49·51587	+ 3·43831	+ 8·32880	+ 0·58394	+ 0·47722	− 5·02220	− 20·52606	− 5·00576	− 3·91241
	− 0·13947	+ 0·06321	+ 0·00920	− 0·22063	+ 0·19197	+ 0·11094	+ 0·03206	− 0·15596	+ 0·03673	− 0·01714	+ 0·50800	− 0·50688
		+108·29043	+ 19·14734	+ 42·37823	− 0·36819	− 6·83897	− 1·51028	+ 9·18761	− 2·26089	− 4·81028	− 3·90356	− 3·85963
		− 0·02865	− 0·00417	+ 0·10000	− 0·08701	− 0·05028	− 0·01453	+ 0·07069	− 0·01665	+ 0·00777	− 0·23025	+ 0·22974
			+142·85786	− 2·61798	− 0·06629	− 1·66186	+ 0·75468	− 0·24642	− 0·15134	+ 0·18468	+ 1·18413	− 0·19977
			− 0·00061	+ 0·01456	− 0·01267	− 0·00732	− 0·00212	+ 0·01029	− 0·00242	+ 0·00113	− 0·03352	+ 0·03345
				+129·38380	− 0·32342	− 2·58467	+ 0·69257	+ 5·61863	− 7·48907	+ 0·69257	− 1·11552	− 0·82334
				− 0·34902	+ 0·30369	+ 0·17550	+ 0·05071	− 0·24671	+ 0·05810	− 0·02712	+ 0·80363	− 0·80185
					+ 7·92528	+ 1·83599	+ 0·01754	− 0·03975	− 0·12711	+ 0·01754	+ 1·91798	− 0·19762
					− 0·26424	− 0·15270	− 0·04412	+ 0·21467	− 0·05056	+ 0·02359	− 0·69925	+ 0·69770
						+ 7·40991	− 1·75083	− 2·14826	− 0·29017	+ 0·24917	− 0·02490	− 0·44084
						− 0·08825	− 0·02550	+ 0·12405	− 0·02922	+ 0·01363	− 0·40409	+ 0·40319
							+ 7·80299	+ 0·06519	+ 0·04003	− 0·19701	+ 1·87722	+ 0·05284
							− 0·00737	+ 0·03584	− 0·00844	+ 0·00394	− 0·11676	+ 0·11650
								+ 7·96267	− 0·07058	+ 0·06519	− 2·00250	− 0·10701
								− 0·17439	+ 0·04107	− 0·01917	+ 0·56806	− 0·56680
									+ 7·78320	+ 0·04003	− 0·13202	− 0·33655
									− 0·00967	+ 0·00451	− 0·13379	+ 0·13349
										+ 7·80299	− 0·12278	+ 0·05284
										− 0·00211	+ 0·06243	− 0·06230
											+ 7·80539	− 0·21216
											− 1·85036	+ 1·84626
												+ 7·47709
												− 1·84218

ELIMINATION 2.—*Continued.*

K_{16}	K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum—* check
− 0·0067003	+0·0019936	− 0·0433056	+ 0·0103360	− 0·0310537	+ 0·0018442	− 0·0654101	− 0·0780467	− 0·0821323	− 0·0204072	− 1·3248613	
− 2·59	− 0·77064	+ 16·73976	− 3·99536	+ 12·00377	− 0·71286	+ 25·28422	+ 30·16888	+ 31·74816	+ 7·88837	+ 512·12400	− 0·3
− 18·25	+ 3·38350	− 13·81662	+ 1·88425	− 4·70933	− 11·87633	− 26·12720	− 22·85933	− 19·18383	− 14·89971	+378·30461	+ 2·1
− 0·04920	+ 0·01464	− 0·31797	+ 0·07589	− 0·22801	+ 0·01354	− 0·48027	− 0·57305	− 0·60305	− 0·14984	− 9·72769	
− 3·22	+ 3·08213	− 0·59692	− 1·11865	+ 3·17296	− 7·67980	+ 37·97203	+ 33·82012	+ 22·69596	+ 0·18653	+205·92534	+ 0·9
+ 0·02230	− 0·00663	+ 0·14412	− 0·03440	+ 0·10334	− 0·00614	+ 0·21768	+ 0·25973	+ 0·27333	+ 0·06791	+ 4·40902	
+ 2·05	− 0·92311	− 0·35040	+ 0·40508	− 4·98705	− 0·01069	+ 5·56226	+ 6·90930	+ 6·17014	− 11·49426	+284·53757	+ 0·2
+ 0·00325	− 0·00097	+ 0·02098	− 0·00501	+ 0·01505	− 0·00089	+ 0·03169	+ 0·03781	+ 0·03979	+ 0·00989	+ 0·64188	
0	− 0·32291	+ 0·78195	− 0·62556	+ 4·78580	− 0·54712	+ 25·88905	+ 21·85395	+ 15·63996	+ 1·01708	+293·41521	− 0·7
− 0·07783	+ 0·02316	− 0·50301	+ 0·12006	− 0·36070	+ 0·02142	− 0·75976	− 0·90653	− 0·95399	− 0·23704	− 15·38862	
0	+ 0·05781	+ 0·06610	+ 2·28722	+ 0·63361	− 0·01385	− 4·89613	− 5·52382	− 3·17650	− 0·18213	− 6·82406	− 0·5
+ 0·06772	− 0·02015	+ 0·43768	− 1·10446	+ 0·31385	− 0·01864	+ 0·66108	+ 0·78879	+ ·83008	+ 0·20625	+ 13·38995	
+ 2·00	− 0·06218	+ 0·23783	− 1·32612	+ 1·44232	− 0·61683	− 9·78360	− 10·14423	− 7·62079	− 0·22416	− 29·85485	− 0·3
+ 0·03913	− 0·01164	+ 0·25293	− 0·06037	+ 0·18137	− 0·01077	+ 0·38203	+ 0·45583	+ 0·47969	+ 0·11919	+ 7·73784	
0	+ 0·15955	− 0·10042	− 0·10716	− 1·41188	− 0·64436	− 1·03515	− 1·14273	− 0·94718	− 2·20258	− 0·69061	− 0·3
+ 0·01131	− 0·00336	+ 0·07308	− 0·01744	+ 0·05241	− 0·00311	+ 0·11039	+ 0·13171	+ 0·13861	+ 0·03444	+ 2·23585	
0	− 0·01938	− 1·94024	+ 0·16432	− 0·31729	− 0·05150	+ 3·74332	+ 4·17808	+ 4·17478	+ 0·06104	+ 36·96556	+ 0·5
− 0·05501	+ 0·01637	− 0·35556	+ 0·08486	− 0·25497	+ 0·01514	− ·53705	− 0·64080	− 0·67435	− 0·16755	− 10·87776	
0	+ 0·08920	− 1·88306	+ 2·49076	+ 0·78674	− 0·03163	− 0·33401	− 1·69898	+ 0·75592	− 0·28101	− 10·05638	− 0·1
+ 0·01296	− 0·00385	+ 0·08374	− 0·01999	+ 0·06005	− 0·00357	+ 0·12648	+ 0·15092	+ 0·15882	+ 0·03946	+ 2·56184	
0	− 1·84045	+ 1·89958	− 0·10716	− 0·11388	+ 8·98564	− 1·49515	− 1·60273	− 1·40718	+ 4·76742	− 6·56261	− 0·3
− 0·00605	+ 0·00180	− 0·03908	+ 0·00933	− 0·02802	+ 0·00166	− 0·05903	− 0·07043	− 0·07412	− 0·01842	− 1·19554	
− 2·00000	− 1·80906	− 1·98996	+ 0·28602	+ 0·80964	+ 0·51700	− 1·16173	− 1·10248	+ 0·91654	+ 3·57855	− 28·43421	+ 0·1
+ 0·17919	− 0·05332	+ 1·15818	− 0·27643	+ 0·83051	− 0·04932	+ 1·74934	+ 2·08730	+ 2·19657	+ 0·54578	+ 35·43241	
0	− 1·85289	+ 2·17768	− 1·23898	+ 1·35908	− 0·04175	+ 2·92790	+ 2·83024	+ 7·11134	+ 3·29659	+ 40·74758	+ 1·2
− 0·17880	+ 0·05320	− 1·15561	+ 0·27582	− 0·82867	+ 0·04921	− 1·74547	− 2·08268	− 2·19170	− 0·54457	− 35·35399	
+ 8·00	− 2·00	− 2·00	0	+ 0·16000	+ 3·81	− 0·46	− 0·46	− 0·46	+ 2·73	+ 28·99000	0
+ 0·01735	+ 0·00516	− 0·11216	+ 0·02677	− 0·08043	+ 0·00478	− 0·16941	− 0·20214	− 0·21272	− 0·05285	− 3·43139	
	+ 5·79989	+ 0·02506	− 0·18658	+ 0·47780	− 5·14604	− 1·64493	− 1·80598	− 3·69433	− 9·42965	− 18·43312	− 0·7
	− 0·00154	− 0·03337	− 0·00797	+ 0·02393	− 0·00142	+ 0·05041	+ 0·06015	+ 0·06329	+ 0·01573	+ 1·02099	
		+ 5·90415	− 0·27160	− 0·75465	+ 0·07933	− 1·07466	− 0·79631	− 0·93472	− 0·07893	+ 1·32293	+ 0·2
		− 0·72493	+ 0·17302	− 0·51983	+ 0·03087	− 1·09495	− 1·30648	− 1·37487	− 0·34161	− 22·17786	
			+ 4·88766	− 1·87340	+ 0·08465	+ 0·18743	+ 0·34860	+ 0·40832	+ 0·58773	+ 3·17150	− 0·7
			− 0·04130	+ 0·12407	− 0·00737	+ 0·26134	+ 0·31182	+ 0·32815	+ 0·08153	+ 5·29330	
					+ 26·68205	+ 45·31935	+ 42·08092	+ 39·18959	+ 31·85959		
					− 0·00131	− 1·65384	− 2·35458	− 2·60755	− 0·16098		

*In units of fourth decimal place.

K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}
$K_4 =$ 34490687	+ 0·09988093	− 0·35527177	− 0·14292333	− 0·01052539	− 0·02446962	− 0·00178599	− 0·00093144	+ 0·01445454	+ 0·05956159	+ 0·01304051	+ 0·01281299
	− 34·44962	+122·51498	+ 49·29524	+ 3·63028	+ 8·43974	+ 0·61600	+ 0·32126	− 4·98547	− 20·54320	− 4·49776	− 4·41929
	+108·26178	+ 19·14317	+ 42·47823	− 0·45520	− 6·88925	− 1·52481	+ 9·25830	− 2·27754	− 4·80251	− 4·13381	− 3·62989
	− 3·44086	+ 12·23691	+ 4·92365	+ 0·36260	+ 0·84297	+ 0·06153	+ 0·03209	− 0·49795	− 2·05187	− 0·44924	− 0·44140
		+142·85725	− 2 60342	− 0·07896	− 1·66918	+ 0·75256	− 0·23613	− 0·15376	+ 0·18581	+ 1·15061	− 0·16632
		− 43·51876	− 17·51025	− 1·28952	− 2·99790	− 0·21881	− 0·11412	+ 1·77090	+ 7·29719	+ 1·59766	+ 1·56978
			+129·03478	− 0·01973	− 2·40917	+ 0·74328	+ 5·37192	− 7·43097	+ 0·66545	− 0·31189	− 1·62519
			− 7·04544	− 0·51885	− 1·20624	− 0·08804	− 0·04595	+ 0·71254	+ 2·93610	+ 0·64284	+ 0·63162
				+ 7·66104	+ 1·68329	− 0·02658	+ 0·17492	− 0·17767	+ 0·04113	+ 1·21873	+ 0·50008
				− 0·03821	− 0·08883	− 0·00648	− 0·00338	+ 0·05247	+ 0·21623	+ 0·04734	+ 0·04651
					+ 7·32166	− 1·77633	− 2·02421	− 0·31939	+ 0·26280	− 0·42899	− 0·03765
					− 0·20652	− 0·01507	− 0·00786	+ 0·12199	+ 0·50268	+ 0·11006	+ 0·10814
						+ 7·79562	+ 0·10103	+ 0·03159	− 0·19307	+ 1·76046	+ 0·16934
						− 0·00110	− 0·00057	+ 0·00891	+ 0·03669	+ 0·00803	+ 0·00789
							+ 7·78828	− 0·02951	+ 0·04602	− 1·43444	− 0·67381
							− 0·00030	+ 0·00464	+ 0·01913	+ 0·00419	+ 0·00412
								+ 7·77353	+ 0·04454	− 0·26581	− 0·20306
								− 0·07206	− 0·29694	− 0·06501	− 0·06388
									+ 7·80088	− 0·06035	− 0·00946
									− 1·22359	− 0·26789	− 0·26322
										+ 5·95503	+ 1·63410
										− 0·05865	− 0·05763
											+ 5·63491
											− 0·05662

K_{16}	K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum* −Check
− 0·05277019	− 0·00985234	+ 0·04098089	− 0·00568310	+ ·01431499	+ 0·03439418	+ 0·07714393	+ 0·06793828	+ 0·05736876	+ 0·04363366	− 1·06362737	
+ 18·20080	+ 3·39814	− 14·13459	+ 1·96014	− 4·93734	− 11·86279	− 26·60747	− 23·43238	− 19·78688	− 15·04955	+368·57692	+1·9
− 3·19770	+ 3·07550	− 0·45280	− 1·15305	+ 3·27630	− 7·68594	+ 38·18971	+ 34·07985	+ 22·96929	+ 0·25444	+210·33436	+0·9
+ 1·81791	+ 0·33941	− 1·41178	+ 0·19578	− 0·49315	− 1·18487	− 2·65758	− 2·34045	− 1·97633	− 1·50316	+ 36·81381	
+ 2·05325	− 0·92408	− 0·32942	+ 0·40007	− 4·97200	− 0·01158	+ 5·59395	+ 6·94711	+ 6·20993	− 11·48437	+285·17945	+0·2
− 6·46514	− 1·20706	+ 5·02077	− 0·69626	+ 1·75380	+ 4·21380	+ 9·45129	+ 8·32346	+ 7·02853	+ 5·34578	−130·92286	
− 0·07783	− 0·29975	+ 0·27894	− 0·50550	+ 4·42510	− 0·52570	+ 25·12929	+ 20·94742	+ 14·68597	+ 0·78004	+278·02659	−0·8
− 2·60132	− 0·48567	+ 2·02016	− 0·28015	+ 0·70566	+ 1·69547	+ 3·80283	+ 3·34903	+ 2·82801	+ 2·15093	− 52·67824	
+ 0·06772	+ 0·03766	+ 0·50378	+ 2·18276	+ 0·94746	− 0·03249	− 4·23505	− 4·73503	− 2·34642	+ 0·02412	+ 6·56589	−0·5
− 0·19157	− 0·03577	+ 0·14877	− 1·02063	+ 0·05197	+ 0·12486	+ 0·28005	+ 0·24663	+ 0·20826	+ 0·15840	− 3·87942	
+ 2·03913	− 0·07382	+ 0·49076	− 1·38649	+ 1·62369	− 0·62760	− 9·40157	− 9·68840	− 7·14110	− 0·10497	− 22·11701	−0·4
− 0·44537	− 0·08315	+ 0·34587	− 0·04796	+ 0·12081	+ 0·29028	+ 0·65107	+ 0·57338	+ 0·48418	+ 0·36826	− 9·01894	
+ 0·01131	+ 0·15619	− 0·02734	− 0·12460	− 1·35947	− 0·64747	− 0·92476	− 1·01102	− 0·80857	− 2·16814	+ 1·54524	−0·2
− 0·03251	− 0·00607	+ 0·02524	− 0·00350	+ 0·00882	+ 0·02119	+ 0·04752	+ 0·04185	+ 0·03534	+ 0·02688	− 0·65827	
− 0·05501	− 0·00301	− 2·29580	+ 0·24918	− 0·57226	− 0·03636	+ 3·20627	+ 3·53728	+ 3·50043	− 0·10651	+ 26·08780	+0·4
− 0·01695	− 0·00317	+ 0·01317	− 0·00183	+ 0·00460	+ 0·01105	+ 0·02478	+ 0·02183	+ 0·01843	+ 0·01402	− 0·34331	
+ 0·01296	+ 0·08535	− 1·79932	+ 2·47077	+ 0·84679	− 0·03520	− 0·20753	− 1·54806	+ 0·91474	− 0·24155	− 7·49454	−0·3
+ 0·26308	+ 0·04912	− 0·20431	+ 0·02833	− 0·07137	− 0·17147	− 0·38460	− 0·33870	− 0·28601	− 0·21753	+ 5·32761	
− 0·00605	− 1·83865	+ 1·86050	− 0·09783	− 0·14190	+ 8·98730	− 1·55418	− 1·67316	− 1·48130	+ 4·74900	− 7·75815	−0·8
+ 1·08407	+ 0·20240	− 0·84188	+ 0·11675	− 0·29408	− 0·70657	− 1·58479	− 1·39567	− 1·17854	− 0·89638	+ 21·95310	
− 1·82081	− 1·86238	− 0·83178	+ 0·00959	+ 1·64015	+ 0·46768	+ 0·58761	+ 0·98482	+ 3·11311	+ 4·12433	+ 6·99820	0·0
+ 0·23735	+ 0·04431	− 0·18432	+ 0·02556	− 0·06439	− 0·15470	− 0·34697	− 0·30557	− 0·25803	− 0·19625	+ 4·80643	
− 0·17880	− 1·79969	+ 1·02207	− 0·96316	+ 0·53041	+ 0·00746	+ 1·18243	+ 0·74756	+ 4·91964	+ 2·75202	+ 5·39359	+1·1
+ 0·23321	+ 0·04354	− 0·18111	+ 0·02512	− 0·06326	− 0·15200	− 0·34092	− 0·30024	− 0·25353	− 0·19283	+ 4·72257	
+ 7·98265	− 1·99484	− 2·11216	+ 0·02677	+ 0·07957	+ 3·81478	− 0·62941	− 0·66214	− 0·67272	+ 2·67715	+ 25·55861	+0·1
− 0·96046	− 0·17932	+ 0·74588	− 0·10344	+ 0·26054	+ 0·62600	+ 1·40408	+ 1·23653	+ 1·04416	+ 0·79417	− 19·44987	
	+ 5·79835	+ 0·05843	− 0·19455	+ 0·50173	− 5·14746	− 1·59452	− 1·74583	− 3·63104	− 9·41392	− 17·41213	−0·6
	− 0·03348	+ 0·13926	− 0·01931	+ 0·04864	+ 0·11688	+ 0·26215	+ 0·23086	+ 0·19495	+ 0·14827	− 3·63135	
		+ 5·17922	− 0·09858	− 1·27448	+ 0·11020	− 2·16961	− 2·10279	− 2·30959	− 0·42054	− 20·85493	+0·3
		− 0·57925	+ 0·08033	− 0·20234	− 0·48615	− 1·09040	− 0·96028	− 0·81088	− 0·61674	+ 15·10461	
			+ 4·84636	− 1·74933	+ 0·07728	+ 0·44877	+ 0·66042	+ 0·73647	+ 0·66926	+ 8·46480	−0·5
			− 0·01114	+ 0·02806	+ 0·06742	+ 0·15121	+ 0·13317	+ 0·11245	+ 0·08553	− 2·09466	
					+ 26·68074	+ 43·66551	+ 39·72634	+ 36·59204	+ 31·69861		
					− 0·40801	− 2·05260	− 1·59196	− 1·13515	− 0·65667		

*In units of the 4th decimal place.

K_7	K_5	K_6	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}
$K_7 =$	− 0·3885740	+ 0·1648806	+ 0·0044150	+ 0·0296371	− 0·0053713	− 0·0436593	+ 0·0550739	− 0·0295235	− 0·0027129	+ 0·0081447	+ 0·0219622
+121·98934	+ 47·40188	− 20·11367	− 0·53858	− 3·61541	+ 0·65524	+ 5·32597	− 6·71843	+ 3·60155	+ 0·33095	− 0·99357	− 2·67915
	+104·82092	+ 31·38008	− 0·09260	− 6·04628	− 1·46328	+ 9·29039	− 2·77549	− 6·85438	− 4·58305	− 4·07129	− 1·37979
	− 18·41914	+ 7·81565	+ 0·20928	+ 1·40485	− 0·25461	− 2·06953	+ 2·61061	− 1·39947	− 0·12860	+ 0·38607	+ 1·04105
		+ 99·33849	− 1·36848	− 4·66708	+ 0·53375	− 0·35025	+ 1·61714	+ 7·48300	+ 2·74827	+ 1·40346	− 4·41189
		− 3·31635	− 0·08880	− 0·59611	+ 0·10804	+ 0·87815	− 1·10774	+ 0·59383	+ 0·05457	− 0·16382	− 0·44174
			+ 7·62283	+ 1·59446	− 0·03306	+ 0·17154	− 0·12520	+ 0·25736	+ 1·26607	+ 0·54659	− 0·12385
			− 0·00238	− 0·01596	+ 0·00289	+ 0·02351	− 0·02966	+ 0·01590	+ 0·00146	− 0·00439	− 0·01183
				+ 7·11514	− 1·79140	− 2·03207	− 0·19740	+ 0·76548	− 0·31893	+ 0·07049	+ 1·59376
				− 0·10715	+ 0·01942	+ 0·15785	− 0·19911	+ 0·10674	+ 0·00981	− 0·02945	− 0·07940
					+ 7·79452	+ 0·10046	+ 0·04050	− 0·15638	+ 1·76849	+ 0·17723	− 0·02120
					− ·00352	− 0·02861	+ 0·03609	− 0·01935	− 0·00178	+ 0·00534	+ 0·01439
						+ 7·78798	− 0·02487	+ 0·06515	− 1·43025	− 0·66969	− 0·07196
						− 0·23253	+ 0·29332	− 0·15724	− 0·01445	+ 0·04338	+ 0·11697
							+ 7·70147	− 0·25240	− 0·33082	− 0·26694	+ 0·27604
							− 0·37001	+ 0·19835	+ 0·01823	− 0·05472	− 0·14755
								+ 6·57729	− 0·32824	− 0·27268	+ 1·07802
								− 0·10633	− 0·00977	+ 0·02933	+ 0·07910
									+ 5·89638	+ 1·57647	− 1·58346
									− 0·00090	+ 0·00270	+ 0·00727
										+ 5·57829	+ 0·05441
										− 0·00809	− 0·02182
											+ 7·02219
											− 0·05884

K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum* −Check
+ 0·0064384	− 0·0188467	+ 0·0064403	− 0·0420591	− 0·0095891	− 0·2371692	− 0·1991686	− 0·1435698	− 0·0240264	− 1·8472790	
− 0·78542	+ 2·29910	− 0·78565	+ 5·13076	+ 1·16977	+ 28·93212	+ 24·29645	+ 17·51398	+ 2·93097	+225·34835	−1·5
+ 3·41491	− 1·86458	− 0·95727	+ 2·78315	− 8·87081	+ 35·53213	+ 31·73940	+ 20·99296	− 1·24872	+247·14817	+1·1
+ 0·30519	− 0·89337	+ 0·30528	− 1·99368	− 0·45454	− 11·24227	− 9·44097	− 6·80548	− 1·13890	− 87·56450	
− 2·13114	+ 4·69135	− 0·29619	− 3·21820	+ 4·20222	+ 15·04524	+ 15·27057	+ 13·23846	− 6·13859	+154·25659	−0·5
− 0·12950	+ 0·37908	− 0·12954	+ 0·84596	+ 0·19287	+ 4·77034	+ 4·00601	+ 2·88772	+ 0·48326	+ 37·15556	
+ 0·00189	+ 0·65255	+ 2·16213	+ 0·99943	+ 0·09237	− 3·95500	− 4·48840	− 2·13816	+ 0·18252	+ 2·68647	−0·6
− 0·00347	+ 0·01015	− 0·00347	+ 0·02265	+ 0·00516	+ 0·12773	+ 0·10727	+ 0·07732	+ 0·01294	+ 0·99491	
− 0·15697	+ 0·83663	− 1·43445	+ 1·74450	− 0·33732	− 8·75050	− 9·11502	− 6·65692	+ 0·26329	− 31·13595	−0·5
− 0·02328	+ 0·06814	− 0·02328	+ 0·15206	+ 0·03467	+ 0·85746	+ 0·72008	+ 0·51906	+ 0·08687	+ 6·67867	
− 0·15012	− 0·00210	− 0·12810	− 1·35065	− 0·62628	− 0·87724	− 0·96917	− 0·77323	− 2·14126	+ 0·88697	−0·1
+ 0·00422	− 0·01235	+ 0·00422	− 0·02756	− 0·00628	− 0·15541	− 0·13051	− 0·09407	− 0·01574	− 1·21043	
− 0·00618	− 2·28263	+ 0·24735	− 0·56766	− 0·02531	+ 3·23105	+ 3·55911	+ 3·51886	− 0·09249	+ 25·74449	+0·1
+ 0·03429	− 0·10038	+ 0·03430	− 0·22401	− 0·05107	− 1·26316	− 1·06077	− 0·76465	− 0·12796	− 9·83855	
+ 0·13447	− 2·00363	+ 2·49910	+ 0·77542	− 0·20667	− 0·59213	− 1·88676	+ 0·62873	− 0·45908	− 2·16693	−0·2
− 0·04326	+ 0·12662	− 0·04327	+ 0·28257	+ 0·06442	+ 1·59340	+ 1·33810	+ 0·96456	+ 0·16142	+ 12·41081	
− 1·63625	+ 1·01862	+ 0·01892	− 0·43598	+ 8·28073	− 3·13897	− 3·06883	− 2·65984	+ 3·85262	+ 14·19495	−1·6
+ 0·02319	− 0·06788	+ 0·02320	− 0·15148	− 0·03454	− 0·85418	− 0·71732	− 0·51707	− 0·08653	− 6·65307	
− 1·81807	− 1·01610	+ 0·03515	+ 1·57576	+ 0·31298	+ 0·24064	+ 0·67925	+ 2·85508	+ 3·92808	+ 11·80463	+0·2
+ 0·00213	− 0·00624	+ 0·00213	− 0·01392	− 0·00317	− 0·07849	− 0·06591	− 0·04751	− 0·00795	− 0·61136	
− 1·75615	+ 0·84096	− 0·93804	+ 0·46715	− 0·14454	+ 0·84151	+ 0·44732	+ 4·66611	+ 2·55919	+ 10·11616	+1·2
− 0·00640	+ 0·01873	− 0·00640	+ 0·04179	+ 0·00953	+ 0·23564	+ 0·19789	+ 0·14265	+ 0·02387	+ 1·83540	
− 2·17416	− 1·36628	− 0·07667	+ 0·34011	+ 4·44078	+ 0·77467	+ 0·57439	+ 0·37144	+ 3·47132	+ 6·10874	−0·2
− 0·01725	+ 0·05049	− 0·01725	+ 0·11268	+ 0·02569	+ 0·63541	+ 0·53360	+ 0·38465	+ 0·06437	+ 4·94914	
+ 5·76487	+ 0·19769	− 0·21386	+ 0·55037	− 5·03058	− 1·33237	− 1·51497	− 3·43609	− 9·26567	− 21·04348	−0·8
− 0·00506	+ 0·01480	− 0·00506	+ 0·03303	+ 0·00753	+ 0·18628	+ 0·15643	+ 0·11276	+ 0·01887	+ 1·45089	
	+ 4·59997	− 0·01825	− 1·47682	− 0·37595	− 3·26001	− 3·06307	− 3·12047	− 1·03728	− 5·75032	+0·2
	− 0·04333	+ 0·01481	− 0·09670	− 0·02205	− 0·54528	− 0·45791	− 0·33008	− 0·05524	− 4·24708	
		+ 4·83522	− 1·72127	+ 0·14470	+ 0·59998	+ 0·79359	+ 0·84892	+ 0·75479	+ 6·37014	−0·4
		− 0·00506	+ 0·03304	+ 0·00753	+ 0·18633	+ 0·15648	+ 0·11280	+ 0·01888	+ 1·45131	
				+ 26·27273	+ 41·61291	+ 38·13438	+ 35·45689	+ 31·04194		
				− 0·01122	− 6·86181	− 4·83909	− 2·51448	− 0· 7042		

*In units of 4th decimal place.

K_6	K_5	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}
K_6=	− 0·4081947	+ 0·0151765	+ 0·0548123	− 0·0066838	− 0·0054977	− 0·0053050	− 0·0841142	− 0·0291895	− 0·0129099	+ 0·0505470
+ 96·02214	+ 39·19573	− 1·45728	− 5·26319	+ 0·64179	+ 0·52790	+ 0·50940	+ 8·07683	+ 2·80284	+ 1·23964	− 4·85363
	86·40178	+ 0·11668	− 4·64143	− 1·71789	+ 7·22086	− 0·16488	− 8·25385	− 4·71165	− 3·68522	− 0·33874
	− 15·99949	+ 0·59485	+ 2·14841	− 0·26198	− 0·21549	− 0·20793	− 3·29692	− 1·14410	− 0·50601	+ 1·98123
		+ 7·62045	+ 1·57850	− 0·03017	+ 0·19505	− 0·15486	+ 0·27326	+ 1·26753	+ 0·54220	− 0·13568
		− 0·02212	− 0·07988	+ 0·00974	+ 0·00801	+ 0·00773	+ 0·12258	+ 0·04254	+ 0·01881	− 0·07366
			+ 7·00799	− 1·77198	− 1·87422	− 0·39651	+ 0·87222	− 0·30912	+ 0·04104	+ 1·51436
			− 0·78849	+ 0·03518	+ 0·02894	+ 0·02792	+ 0·44271	+ 0·15363	+ 0·06795	− 0·26604
				+ 7·79100	+ 0·07185	+ 0·07659	− 0·17573	+ 1·76671	+ 0·18259	− 0·00681
				− 0·00429	− 0·00353	− 0·00340	− 0·05398	− 0·01873	− 0·00829	+ 0·03244
					+ 7·55545	+ 0·26845	− 0·09209	− 1·44470	− 0·62631	+ 0·04501
					− 0·00290	− 0·00280	− 0·04440	− 0·01541	− 0·00682	+ 0·02668
						+ 7·33146	− 0·05405	− 0·31259	− 0·32166	+ 0·12849
						− 0·00270	− 0·04255	− 0·01487	− 0·00658	+ 0·02575
							+ 6·47096	− 0·33801	− 0·24335	+ 1·15712
							− 0·67938	− 0·23576	− 0·10427	+ 0·40826
								+ 5·89548	+ 1·57917	− 1·57619
								− 0·08181	− 0·03618	+ 0·14168
									5·57020	+ 0·03259
									− 0·01600	+ 0·06266
										6·96335
										− 0·24534

K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
+ 0·0235429	− 0·0528048	+ 0·0042337	+ 0·0247051	− 0·0457716	− 0·2063647	− 0·2007514	− 0·1679423	+ 0·0588961	− 1·9934168	
− 2·26064	+ 5·07043	− 0·42573	− 2·37224	+ 4·39509	+ 19·81558	+ 19·27658	+ 16·12618	− 5·65533	+ 191·41215	− 0·6
+ 3·72010	− 2·75795	− 0·65199	+ 0·78947	− 9·32535	+ 24·28986	+ 22·29843	+ 14·18748	− 2·38762	+ 159·58367	+ 1·5
+ 0·92278	− 2·06972	+ 0·17378	+ 0·96833	− 1·79405	− 8·08862	− 7·86860	− 6·58262	+ 2·30848	− 78·13343	
− 0·00158	+ 0·66270	+ 2·15866	+ 1·02208	+ 0·09753	− 3·82727	− 4·38113	− 2·06084	+ 0·19546	+ 3·68138	− 0·9
− 0·03431	+ 0·07695	− 0·00646	− 0·03600	+ 0·06670	+ 0·30073	+ 0·29255	+ 0·24474	− 0·08583	+ 2·90497	
− 0·18025	+ 0·90477	− 1·45773	+ 1·89656	− 0·30267	− 7·89304	− 8·39494	− 6·13786	+ 0·35016	− 24·45728	− 0·6
− 0·12391	+ 0·27792	− 0·02334	− 0·13003	+ 0·24090	+ 1·08614	+ 1·05659	+ 0·88391	− 0·30998	+ 10·49173	
+ 0·15434	− 0·01445	− 0·12388	− 1·37821	− 0·63256	− 1·03265	− 1·09968	− 0·86730	− 2·15700	− 0·32346	+ 0·2
+ 0·01511	− 0·03389	+ 0·00285	+ 0·01586	− 0·02938	− 0·13244	− 0·12884	− 0·10778	+ 0·03780	− 1·27935	
+ 0·02811	− 2·38301	+ 0·28165	− 0·79167	− 0·07638	+ 1·96789	+ 2·49834	+ 2·75421	− 0·22045	+ 15·90594	− 0·2
+ 0·01243	− 0·02788	+ 0·00234	+ 0·01304	− 0·02416	− 0·10894	− 0·10598	− 0·08866	+ 0·03109	− 1·05232	
+ 0·09121	− 1·87701	+ 2·45583	+ 1·05799	− 0·14225	+ 1·00127	− 0·54866	+ 1·59329	− 0·29766	+ 10·24388	− 0·3
+ 0·01199	− 0·02690	+ 0·00226	+ 0·01258	− 0·02332	− 0·10512	− 0·10226	− 0·08555	+ 0·03000	− 1·01545	
− 1·61306	+ 0·95074	+ 0·04212	− 0·58746	+ 8·24619	− 3·99315	− 3·78615	− 3·17691	+ 3·76609	+ 7·54188	− 1·6
+ 0·19015	− 0·42650	+ 0·03581	+ 0·19954	− 0·36969	− 1·66677	− 1·62143	− 1·35644	+ 0·47569	− 16·10049	
− 1·81594	− 1·02234	+ 0·03728	+ 1·56184	+ 0·30981	+ 0·16215	+ 0·61334	+ 2·80757	+ 3·92013	+ 11·19327	+ 0·4
+ 0·06599	− 0·14800	+ 0·01243	+ 0·06924	− 0·12829	− 0·57841	− 0·56267	− 0·47072	+ 0·16508	− 5·58723	
− 0·76255	+ 0·85969	− 0·94444	+ 0·50894	− 0·13501	+ 1·07715	+ 0·64521	+ 4·80876	+ 2·58306	+ 11·95156	+ 1·4
+ 0·02918	− 0·06546	+ 0·00550	+ 0·03063	− 0·05674	− 0·25582	− 0·24886	− 0·20819	+ 0·07301	− 2·47112	
− 2·19141	− 1·37579	− 0·09392	+ 0·45279	+ 4·46647	+ 1·41008	+ 0·10799	+ 0·75609	+ 3·53569	+ 11·05788	− 0·2
− 0·11427	+ 0·25629	− 0·02152	− 0·11991	+ 0·22216	+ 1·00162	+ 0·97437	+ 0·81513	− 0·28586	+ 9·67531	
5·75981	+ 0·21249	− 0·21892	+ 0·58340	− 5·02305	− 1·14609	− 0·35854	− 3·32333	− 9·24680	− 19·59259	− 1·1
− 0·05322	+ 0·11937	− 0·01002	− 0·05585	+ 0·10347	+ 0·46652	+ 0·45383	+ 0·37966	− 0·13314	+ 4·50640	
	4·55664	− 0·00344	− 1·57352	− 0·39800	− 3·80529	− 3·52098	− 3·45055	− 1·09252	− 9·99740	+ 0·1
	− 0·26774	+ 0·02248	+ 0·12527	− 0·23208	− 1·04636	− 1·01790	− 0·85154	+ 0·29863	− 10·10748	
		+ 4·83016	− 1·68823	+ 0·15223	+ 0·78631	+ 0·95007	+ 0·96172	+ 0·77367	− 7·82145	− 0·3
		− 0·00189	− 0·01052	+ 0·01949	+ 0·08786	+ 0·08547	+ 0·07150	− 0·02507	+ 0·84866	
				+ 26·26151	+ 34·75110	+ 33·29529	+ 32·94241	+ 30·97152		
				− 0·20117	− 4·08924	− 3·86980	− 2·70827	− 0·33308		

*In units of 4th decimal place

ELIMINATION 6

K_6	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}
$K_6 =$ 70·40229	− 0·010107	+ 0·035411	+ 0·028122	− 0·099505	+ 0·005295	+ 0·164068	+ 0·083176	+ 0·059533	− 0·023330	− 0·065948
	+ 0·71153	+ 2·49302	+ 1·97987	+ 7·00537	+ 0·37281	+ 11·55077	+ 5·85575	+ 4·19123	− 1·64249	+ 4·64288
	+ 7·59833	+ 1·49802	+ 0·02043	+ 0·20306	+ 0·14713	+ 0·39584	+ 1·31007	+ 0·56101	− 0·20934	− 0·03589
	− 0·00719	+ 0·02520	− 0·02001	− 0·07080	− 0·00377	+ 0·11674	+ 0·05918	+ 0·04236	− 0·01660	− 0·04692
		+ 6·71950	+ 1·73680	− 1·84528	− 0·36859	+ 1·31493	+ 0·15549	+ 0·10899	− 1·24832	− 0·30416
		+ 0·08828	+ 0·07011	− 0·24807	− 0·01320	+ 0·40902	+ 0·20736	+ 0·14842	− 0·05816	− 0·16441
			+ 7·78671	− 0·06832	− 0·07319	+ 0·22971	+ 1·74798	+ 0·17430	− 0·02563	− 0·16945
			+ 0·05568	− 0·19701	− 0·01048	+ 0·32483	+ 0·16468	+ 0·11787	− 0·04619	− 0·13057
				− 7·55235	+ 0·26565	+ 0·13649	+ 1·46011	+ 0·63313	− 0·07169	− 0·04054
				− 0·69707	+ 0·03709	+ 1·14936	+ 0·58268	+ 0·41705	− 0·16344	− 0·46199
					+ 7·32876	+ 0·09690	+ 0·32746	+ 0·37824	− 0·15424	− 0·10320
					+ 0·00197	+ 0·06117	+ 0·03101	+ 0·02219	− 0·00870	− 0·02459
						+ 5·79158	+ 0·57377	+ 0·34762	− 1·56538	− 1·42291
						+ 1·89511	+ 0·96075	+ 0·68765	− 0·26948	− 0·76175
							+ 5·81367	+ 1·54299	− 1·43451	− 1·74995
							+ 0·48706	+ 0·34861	− 0·13661	− 0·38618
								+ 5·55420	− 0·09525	− 1·73337
								+ 0·24952	− 0·09778	− 0·27640
									− 6·71801	− 2·30568
									− 0·03832	− 0·10832
										− 5·70659
										− 0·36619

ELIMINATION 6—*Continued.*

K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum—Check*
+ 0·068573	+ 0·006793	− 0·024968	+ 0·157941	− 0·230124	− 0·204963	− 0·108020	+ 0·001124	− 1·156926	
− 4·82767	− 0·47821	+ 1·75780	− 11·11940	+ 16·20124	+ 14·42983	+ 7·60486	− 0·07914	+ 81·45024	+ 1·8
+ 0·73965	+ 2·15220	+ 0·98608	+ 0·16423	− 3·52654	− 4·08858	− 1·81610	+ 0·10963	+ 6·58635	− 1·1
+ 0·04879	+ 0·00483	− 0·01777	+ 0·11238	− 0·16374	− 0·14584	− 0·07686	+ 0·00080	− 0·82319	
+ 1·18269	− 1·48107	+ 1·76653	− 0·06177	− 6·80690	− 7·33835	− 5·25395	+ 0·04018	− 13·96555	− 0·7
− 0·17095	− 0·01694	+ 0·06225	− 0·39375	+ 0·57370	+ 0·51098	+ 0·26930	− 0·00280	+ 2·88424	
− 0·04834	0·12103	− 1·36235	− 0·66194	− 1·16509	− 1·22852	− 0·97508	− 2·11920	− 1·60281	+ 0·3
− 0·13577	− 0·01345	+ 0·04943	− 0·31270	+ 0·45562	+ 0·40580	+ 0·21387	− 0·00223	+ 2·29056	
− 2·41089	+ 0·28399	− 0·77863	− 0·10054	+ 1·85895	+ 2·39236	+ 2·66555	− 0·18936	+ 14·85362	− 0·2
+ 0·48038	+ 0·04759	− 0·17491	+ 1·10644	− 1·61210	− 1·43584	− 0·75672	+ 0·00787	− 8·10469	
− 1·90391	+ 2·45809	+ 1·07057	− 0·16557	+ 0·89615	− 0·65092	+ 1·50774	− 0·26766	+ 9·22843	− 0·3
− 0·02556	− 0·00253	+ 0·00931	− 0·05888	+ 0·08579	+ 0·07641	+ 0·04027	− 0·00042	+ 0·43131	
+ 0·52424	+ 0·07793	− 0·38792	+ 7·87650	− 5·65992	− 5·40758	− 4·53335	+ 4·24178	− 8·55861	− 0·8
− 0·79207	− 0·07846	+ 0·28840	− 1·82434	+ 2·65811	+ 2·36748	+ 1·24771	− 0·01298	+ 13·36339	
− 1·17034	+ 0·04971	+ 1·63108	+ 0·18152	− 0·41626	+ 0·05067	+ 2·33685	+ 4·08521	+ 5·60604	+ 0·7
− 0·40155	− 0·03978	+ 0·14621	− 0·92486	+ 1·34755	+ 1·20021	+ 0·63254	− 0·00658	+ 6·77467	
+ 0·79423	− 0·93894	+ 0·53957	− 0·19175	+ 0·82133	+ 0·39635	+ 4·60057	+ 2·65607	+ 9·48044	+ 1·4
− 0·28741	− 0·02847	+ 0·10465	− 0·66197	+ 0·96450	+ 0·85905	+ 0·45274	− 0·00471	+ 4·84894	
− 1·05950	− 0·11544	+ 0·33288	+ 4·68863	+ 2·41170	+ 2·08236	+ 1·57122	+ 3·24983	+ 20·73319	− 0·3
+ 0·11263	+ 0·01116	− 0·04101	+ 0·25942	− 0·37798	− 0·33665	− 0·17742	+ 0·00185	− 1·90024	
+ 0·33186	− 0·22894	+ 0·52755	− 4·91958	− 0·67957	− 0·90471	− 2·94367	− 9·37994	− 15·08619	− 1·1
+ 0·31838	+ 0·03154	− 0·11592	+ 0·73330	− 1·06844	− 0·95162	− 0·50152	+ 0·00522	− 5·37147	
+ 4·28890	+ 0·01904	− 1·44825	− 0·63008	− 4·85165	− 4·53888	− 4·30209	− 0·79389	− 20·10488	0·0
− 0·33105	− 0·03279	+ 0·12054	− 0·76249	+ 1·11096	+ 0·98949	+ 0·52148	− 0·00543	+ 5·58526	
	+ 4·82827	− 1·69875	+ 0·17172	+ 0·87417	+ 1·03554	+ 1·03322	+ 0·74862	+ 8·67011	+ 0·1
	− 0·00325	+ 0·01194	− 0·07553	+ 0·11005	+ 0·09802	+ 0·05166	− 0·00054	+ 0·55325	
			26·06034	30·66186	29·42549	30·23414	30·63844		
			− 1·75621	− 3·72829	− 2·95758	− 0·82148	− 0·00009		

*In units of 4th decimal place

K_{10}	K_8	K_9	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}
$K_{10}=$	+0·000054	+0·233722	−0·034320	−0·008111	+0·071729	−0·204798	−0·007299	−0·009290	−0·038807
+7·73103	−0·00042	−1·80691	+0·26533	+0·06271	−0·55454	+1·58330	+0·05643	+0·07182	+0·30002
	7·59114	+1·52382	+0·13226	−0·14336	+0·51258	+1·36925	+0·60337	−0·22594	−0·08281
	−0·00000	−0·000098	+0·000014	+0·000003	−0·000030	+0·000086	0	0	+0·00002
		+6·63122	−1·59721	−0·38179	+0·90591	−0·36285	−0·03943	+1·30648	−0·13975
		−0·42231	+0·0620	+0·01466	−0·12961	+0·37005	+0·01319	+0·01679	+0·07012
			+6·85548	+0·30274	+1·01287	−0·87743	−0·21608	−0·09175	−0·42145
			−0·00911	−0·00215	+0·01903	−0·05434	−0·00194	−0·00246	−0·01030
				+7·32679	−0·15807	−0·35847	−0·35043	+0·16294	+0·12779
				−0·00051	+0·00450	−0·01284	−0·00046	−0·00058	−0·00243
					+3·89647	−1·53452	−1·03527	+1·83486	−0·66116
					−0·03978	+0·11357	+0·00405	+0·00515	+0·02152
						+5·32661	+1·19438	−1·29790	−1·36377
						−0·32426	−0·01156	−0·01471	−0·06144
							+5·30468	+0·19303	−1·45697
							−0·00041	−0·00052	−0·00219
								+6·67969	−2·41400
								−0·00067	−0·00279
									+5·40040
									−0·01164

K_{18}	K_{19}	Absolute term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum − Check*
+0·023814	+0·017395	+0·169825	+0·126069	+0·091769	+0·106418	+0·098462	+0·274405	−0·088960	
−0·18411	−0·13448	−1·31292	−0·97464	−0·70947	−0·82272	−0·76121	−2·12143	+0·68775	0·0
+0·78844	+2·15703	+0·96831	+0·27661	−3·69028	−4·23442	−1·89296	+0·11043	+5·76316	−1·1
−0·00001	−0·00001	−0·00007	−0·00005	−0·00004	−0·00004	−0·00004	−0·00016	+0·00004	
+1·01174	−1·49801	+1·82878	−0·45552	−6·23320	−6·82737	−4·98465	+0·03738	−11·08131	−0·5
−0·04303	−0·03143	−0·30686	−0·22780	−0·16582	−0·19229	−0·17791	−0·49583	+ 0·16074	
−1·93051	+0·33158	−0·95354	+1·00590	+0·24685	+0·95652	+1·90883	−0·18149	+ 6·74893	−0·3
+0·00632	+0·00462	+0·04506	+0·03345	+0·02435	+0·02824	+0·02612	+0·07281	− 0·02360	
−1·92947	+2·45556	+1·07988	−0·22445	+0·98194	−0·57451	+1·54801	−0·26808	+ 9·65974	−0·1
+0·00149	+0·00110	+0·01065	+0·00791	+0·00575	+0·00667	+0·00617	+0·01721	− 0·00558	
−0·26783	−0·00053	−0·09952	+6·05216	−3·00181	−3·04010	−3·28564	+4·22880	+ 4·80478	−1·2
−0·01321	−0·00965	−0·09417	−0·06991	−0·05089	−0·05901	−0·05460	−0·15217	+ 0·04933	
−1·57189	+0·00993	+1·77729	−0·74334	+0·93129	+1·25088	+2·96939	+4·07863	+12·38071	+0·7
+0·03770	+0·02754	+0·26888	+0·19960	+0·14530	+0·16849	+0·15589	+0·43447	− 0·14085	
+0·50682	−0·96741	+0·64422	−0·85372	+1·78583	+1·25540	+5·05331	+2·65136	+14·32938	+1·4
+0·00134	+0·00098	+0·00958	+0·00711	+0·00518	+0·00601	+0·00556	+0·01548	− 0·00502	
−0·94687	−0·10428	+0·29187	+4·94805	+2·03372	+1·74571	+1·39380	+3·25168	+18·83295	−0·4
+0·00171	+0·00125	+0·01220	+0·00905	+0·00659	+0·00764	+0·00707	+0·01971	− 0·00639	
+0·65024	−0·19740	+0·41163	−4·18628	−1·74801	−1·85633	−3·44519	−9·37472	−20·45766	−1·0
+0·00714	+0·00522	+0·05095	+0·03782	+0·02753	+0·03193	+0·02954	+0·08233	− 0·02669	
+3·95785	−0·01375	−1·32771	−1·39257	+3·74069	−3·54939	−3·78061	−0·79932	−14·51962	−0·1
−0·00438	−0·00321	−0·03127	−0·02321	−0·01690	−0·01959	−0·01813	−0·05052	+ 0·01638	
	+4·82502	−1·68681	+0·09619	+0·98422	+1·13356	+1·08488	+0·74808	+ 9·22336	+0·2
	0·00234	−0·02284	−0·01695	−0·01234	−0·01431	−0·01324	−0·03690	+ 0·01196	
		24·30413	26·933575	26·46791	29·41266	30·63835	−0·58213		
			−0·12287	−0·06511	−0·08755	−0·07495			

*In units of 4th decimal place.

K_8	K_9	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}
$K_8=$	−0·200723	−0·017424	+0·018885	−0·067520	−0·18037	−0·079483	+0·029764	+0·010906
+7·59114	+1·52372	+0·13227	−0·14336	+0·51255	+1·36934	+0·60337	−0·22594	−0·08279
	+6·20891	−1·53520	−0·36713	+0·77630	+0·00720	−0·02624	+1·32327	−0·06963
	−0·30585	−0·02655	+0·02878	−0·10288	−0·27486	−0·12111	+0·04535	+0·01662
		+6·84637	+0·30059	+1·03190	−0·93177	−0·21802	−0·09421	−0·43175
		−0·00230	+0·00250	−0·00893	−0·02386	−0·01051	+0·00394	+0·00144
			+7·32628	−0·15357	−0·37131	−0·35089	+0·16236	+0·12536
			−0·00271	+0·00968	+0·02586	+0·01139	−0·00427	−0·00156
				+3·85669	−1·42095	−1·03122	+1·84001	−0·63964
				−0·03461	−0·09246	−0·04074	+0·01526	+0·00559
					+5·00235	+1·18282	−1·31261	−1·42521
					−0·24701	−0·19884	+0·04076	+0·01493
						+5·30427	+0·19251	−1·45916
						−0·04796	+0·01796	+0·00658
							+6·67902	−2·41679
							−0·00672	−0·00246
								5·38876
								−0·00090

K_{18}	K_{19}	Absolute Term.	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
−0·103862	−0·284152	−0·127549	−0·036432	+0·486135	+0·557816	+0·249359	−0·014526	−0·759201	
+0·78843	+2·15704	+0·96824	+0·27656	−3·69032	−4·23446	−1·89292	+0·11027	5·76320	−1·6
+0·96871	−1·52944	+1·52192	−0·68332	−6·39902	−7·01966	−5·16256	−0·45845	−10·92057	−0·5
−0·15826	−0·43297	−0·19435	−0·05551	+0·74073	+0·84996	+0·37995	−0·02213	− 1·15681	
−1·92419	+0·33620	−0·90848	+1·03935	+0·27120	+0·98476	+1·93495	−0·10868	+ 6·72533	−0·4
−0·01374	−0·03758	−0·01687	−0·00482	+0·06430	+0·07378	+0·03298	−0·00192	− 0·10042	
−1·92798	+2·45666	+1·09053	−0·21654	+0·98769	−0·56784	+1·55418	−0·25087	+ 9·65416	0·0
+0·01489	+0·04074	+0·01829	+0·00522	−0·06969	−0·07997	−0·03575	+0·00208	+ 0·10884	
−0·28104	−0·01018	−0·19369	+5·98225	−3·05270	−3·09911	−3·34024	+4·07663	+4·85411	−1·2
−0·05323	−0·14564	−0·06538	−0·01867	+0·24917	+0·28591	+0·12781	−0·00745	−0·38913	
−1·53419	+0·03747	+2·04617	−0·54374	+1·07659	+1·41937	+3·12528	+4·51310	+12·23986	+0·5
−0·14222	−0·38910	−0·17466	−0·04989	+0·66568	+0·76384	+0·34146	−0·01989	−1·03960	
+0·50816	−0·96643	+0·65380	−0·84661	+1·79101	+1·26141	+5·05887	+2·66684	+14·32436	+1·3
−0·06267	−0·17145	−0·07696	−0·02198	+0·29332	+0·33657	+0·15046	−0·00876	−0·45808	
−0·94516	−0·10303	+0·30407	+4·95710	+2·04031	+1·75335	+1·40087	+3·27139	+18·82656	−0·4
+0·02347	+0·06420	+0·02882	+0·00823	−0·10984	−0·12603	−0·05634	+0·00328	+0·17153	
+0·65738	−0·19218	+0·46258	−4·14846	−1·72048	−1·82440	−3·41565	−9·29239	−20·48435	−1·0
+0·00860	+0·02352	+0·01056	+0·00302	−0·04025	−0·04618	−0·02064	+0·00120	+0·06285	
+3·95347	−0·01696	−1·35898	−1·41578	−3·75759	−3·56898	−3·79874	−0·84984	−14·50324	−0·4
−0·08189	−0·22403	−0·10056	−0·02872	+0·38328	+0·43980	+0·19660	−0·01145	−0·59858	
	+4·82268	−1·70965	+0·07924	+0·97188	+1·11925	+1·07164	+0·71118	+ 9·23532	+0·5
	−0·61293	−0·27513	−0·07859	+1·04861	+1·20323	+0·53788	−0·03133	− 1·63763	
			24·18126	26·86846	26·38036	29·33771	30·05622		
			−0·01008	−1·79399	−2·36205	−0·47202	−0·00160		

*In units of 4th decimal place.

K_{12}	K_9	K_{11}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}
K_{12}=	+0·046200	−0·041386	+0·019648	+0·047170	+0·046357	−0·021586	−0·016904	+0·261224
+0·732357	−0·33835	+0·30309	−0·14389	−0·34545	−0·33950	+0·15809	+0·12380	−1·91309
	+5·90306	−1·56175	+0·67342	−0·26766	−0·14735	+1·36862	−0·05301	+0·81045
	−0·01563	+0·014 0	−0·00665	−0·01596	−0·01568	+0·00730	+0·00572	−0·08839
		+6·84407	+1·02297	−0·95563	−0·22853	−0·09027	−0·43031	−1·93793
		−0·01254	+0·00596	+0·01430	+0·01405	−0·00654	−0·00512	+0·07917
			+3·82208	−1·51341	−1·07196	+1·85527	−0·63405	−0·33427
			−0·00283	−0·00679	−0·00667	+0·00311	+0·00243	−0·03759
				+4·75534	+1·07398	−1·27185	−1·41028	−1·67641
				−0·01629	−0·01601	+0·00746	+0·00584	−0·09024
					+5·25631	+0·21047	−1·45258	+0·44549
					−0·01574	+0·00733	+0·00574	−0·08869
						+6·67230	−2·41925	−0·92169
						−0·00341	−0·00267	+0·04130
							+5·38786	+0·66598
							−0·00209	+0·03234
								+3·87158
								−0·49975

K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
−0·341009	−0·151404	+0·028855	−0·125349	+0·088455	−0·207335	+0·033971	−1·333093	
+2·49740	+1·10882	−0·21132	+0·91800	−0·64781	+1·51843	−0·24879	+9·76300	0·0
−1·96241	+1·32757	−0·73883	−5·65829	−6·16970	−4·78261	−0·48058	−12·07738	−0·4
+0·11538	+0·05123	−0·00976	+0·04241	−0·02993	+0·07015	−0·01149	+0·45105	
+0·29862	−0·92535	+1·03453	+0·33550	+1·05854	+1·96793	−0·11060	+6·62491	−0·3
−0·10336	−0·04589	+0·00875	−0·03799	+0·02681	−0·06284	+0·01030	−0·40405	
−0·15582	−0·25907	+5·96358	−2·80353	−2·81320	−3·21243	+4·06918	+4·46498	−1·1
+0·04907	+0·02179	−0·00415	+0·01804	−0·01273	+0·02983	−0·00489	+0·19182	
−0·35163	+1·87151	−0·59363	+1·74227	+2·18321	+3·46674	+4·49321	+11·20026	+0·5
+0·11780	+0·05230	−0·00997	+0·04330	−0·03056	+0·07162	−0·01174	+0·46052	
−1·13788	+0·57684	−0·86859	+2·08433	+1·59798	+5·20933	+2·65808	+13·86628	+1·4
+0·11577	+0·05140	−0·00980	+0·04256	−0·03003	+0·07039	−0·01153	+0·45259	
−0·03883	+0·33289	+4·96533	+1·93047	+1·62732	+1·34453	+3·27467	+18·99809	−0·2
−0·05391	−0·02394	+0·00456	−0·01982	+0·01398	−0·03278	+0·00537	−0·21075	
−0·16866	+0·47314	−4·14544	−1·76073	−1·87058	−3·43629	−9·29119	−20·42150	−0·9
−0·04222	−0·01874	+0·00357	−0·01552	+0·01095	−0·02567	+0·00421	−0·16504	
−0·24099	−1·45954	−1·44450	−3·37431	−3·12918	−3·60214	−0·86129	−15·10182	−0·2
+0·65238	+0·28965	−0·05520	+0·23980	−0·16922	+0·39665	−0·06499	+2·55033	
+4·20975	−1·98478	+0·00065	+2·02049	+2·32248	+1·60952	+0·67985	+7·59769	+·07
−0·85164	−0·37812	+0·07206	−0·31305	+0·22091	−0·51780	+0·08484	−3·32927	
		24·17118	25·07447	24·01831	28·86569	30·05462		
		−0·00610	−0·11507	−0·05730	−0·31482	−0·00845		

*In units of 4th decimal place.

ELIMINATION 10

K_{11}	K_{16}	K_9	K_{13}	K_{14}	K_{15}	K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum* −Check
K_{11}=	+0·014171	+0·226560	−0·150615	+0·137792	+0·031396	+0·063738	+0·272085	−0·028582	+0·142170	− 0·152715	− 0·043550	− 0·158874	− 0·278867	+ 0·014682	− 0·910610	
+6·83153	−0·09681	−1·54775	+1·02893	−0·94133	−0·21448	−0·43543	−1·85876	+0·19526	−0·97124	+ 1·04328	+ 0·29751	+ 1·08535	+ 1·90509	− 0·10030	+ 6·22086	−0·1
	+6·66889	+1·37592	+1·85838	−1·26439	+0·21780	−2·42192	−0·88039	−0·09274	+0·30895	+ 4·96989	+ 1·91065	+ 1·64130	+ 1·31175	+ 3·28004	+18·78734	−0·2
	−0·00137	−0·02193	+0·01458	−0·01334	−0·00304	−0·00617	−0·02634	+0·00277	+0·01376	+ 0·01478	+ 0·00422	+ 0·01538	+ 0·02700	− 0·00142	+ 0·08816	
		+5·88743	+0·66677	−0·28362	−0·16303	−0·04129	+0·72206	−1·84703	+1·37880	− 0·74859	− 5·61588	− 6·19963	− 4·71246	− 0·49207	−11·62633	−0·4
		−0·35066	+0·23311	−0·21327	−0·04859	−0·09865	−0·42112	+0·04424	−0·22004	+ 0·23636	+ 0·06740	+ 0·24590	+ 0·43162	− 0·02272	+ 1·40940	
			+3·81925	−1·52020	−1·07863	−0·63162	−0·37186	−0·10675	−0·23728	+ 5·95943	− 2·78549	− 2·82593	− 3·18260	+ 4·06429	+ 4·65680	−1·1
			−0·15497	+0·14178	+0·03230	+0·06558	+0·27996	−0·02941	+0·14628	− 0·15713	− 0·04481	− 0·16347	− 0·18693	+ 0·01511	− 0·93695	
				+4·73905	+1·05797	−1·40444	−1·76665	−0·23383	+1·92381	− 0·60360	+ 1·78557	+ 2·15265	+ 3·53836	+ 4·48147	+11·66078	+0·4
				−0·12971	−0·02955	−0·06000	−0·25612	+0·02691	−0·13383	+ 0·14376	+ 0·04099	+ 0·14955	+ 0·26251	− 0·01382	+ 0·85718	
					+5·24057	−1·44684	+0·35680	−1·02211	+0·62824	− 0·87839	+ 2·12689	+ 1·56795	+ 5·27972	+ 2·64655	+14·31887	+1·4
					−0·00673	−0·01367	−0·05836	+0·00613	−0·03049	+ 0·03275	+ 0·00934	+ 0·03408	+ 0·05981	− 0·00315	+ 0·19531	
						+5·38577	+0·69832	−0·21088	+0·45440	− 4·14187	− 1·77625	− 1·85963	− 3·46196	− 9·28698	−20·58654	−0·8
						−0·02775	−0·11847	+0·01245	−0·06191	+ 0·06650	+ 0·01896	+ 0·06918	+ 0·12143	− 0·00639	+ 0·39651	
							+3·37183	+0·41139	−1·16989	− 1·49970	− 3·13451	− 3·29840	− 3·20549	− 0·92628	−12·55149	−0·4
							−0·50574	+0·05313	−0·26426	+ 0·28386	+ 0·08095	+ 0·29531	+ 0·51835	− 0·02729	+ 1·69261	
								+3·35811	−2·36290	+ 0·07271	+ 1·70744	+ 2·54339	+ 1·09172	+ 0·76469	+ 4·26842	+0·5
								−0·00558	+0·02776	− 0·02982	− 0·00850	− 0·03102	− 0·05445	+ 0·00287	− 0·17780	
										24·16508	24·95940	23·96101	28·55087	30·04617		
										− 0·15932	− 0·01296	− 0·17243	− 0·53127	− 0·00147		

*In units of 4th decimal place.

ELIMINATION 11

K_{16}	K_9	K_{13}	K_{14}	K_{15}	K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Check* −Sum
K_{16}=	−0·203073	−0·280908	+0·191635	−0·032210	+0·364167	+ 0·135992	+ 0·013494	− 0·044273	− 0·747605	− 0·287194	− 0·248470	− 0·200787	− 0·491730	− 2·830963	
6·66752	+1·35399	+1·87296	−1·27773	0·21476	−2·42809	− 0·90673	− 0·08997	0·29519	4·98467	1·91487	1·65668	1·33875	3·27862	18·87550	−0·1
	+5·53677	+0·89988	−0·49689	−0·21162	−0·14594	+ 0·30094	− 1·80279	+ 1·15876	− 0·51223	− 5·54848	− 5·95373	− 4·28084	− 0·51479	−10·21693	−0·4
	−0·27496	−0·38035	+0·25947	−0·04361	+0·49308	+ 0·18413	+ 0·01827	− 0·05995	− 1·01225	− 0·38886	− 0·33643	− 0·27186	− 0·66580	− 3·83310	
		+3·66428	−1·37842	−1·04633	−0·56604	− 0·09190	− 0·13616	− 0·09100	+ 5·80230	− 2·83030	− 2·98940	− 3·46953	+ 4·07940	+ 3·71985	−1·1
		−0·52613	+0·35892	−0·06033	+0·68207	+ 0·25471	+ 0·02527	− 0·08292	− 1·40023	− 0·53790	− 0·46537	− 0·37607	− 0·92099	− 5·30228	
			+4·60934	+1·02842	−1·46444	− 2·02277	− 0·20692	+ 1·78998	− 0·45984	+ 1·82656	+ 2·30220	+ 3·80087	+ 4·46765	+12·51796	+0·5
			−0·24486	+0·04116	−0·46531	− 0·17376	− 0·01724	+ 0·05657	+ 0·95524	+ 0·36696	+ 0·31748	+ 0·25655	+ 0·62830	+ 3·61720	
				+5·23384	−1·46051	+ 0·29844	− 1·01598	+ 0·59775	− 0·84564	+ 2·13623	+ 1·60203	+ 5·33953	+ 2·64340	+14·51418	+1·4
				−0·00692	+0·07821	+ 0·02921	+ 0·00290	− 0·00951	− 0·16056	− 0·06168	− 0·05336	− 0·04312	− 0·10560	− 0·60798	
					+5·35802	+ 0·57985	− 0·19843	+ 0·39249	− 4·07537	− 1·75729	− 1·79045	− 3·34053	− 9·29337	−20·19003	−0·7
					−0·88423	− 0·33020	− 0·03276	+ 0·10750	+ 1·81525	+ 0·69730	+ 0·60331	+ 0·48753	+ 1·19396	+ 6·87383	
						+ 2·86609	+ 0·46452	− 1·43415	− 1·21584	− 3·05356	− 3·00309	− 2·68714	− 0·95357	−10·85888	−0·3
						− 0·12331	− 0·01224	+ 0·04014	+ 0·67788	+ 0·26041	+ 0·22530	+ 0·18206	+ 0·44587	+ 2·56692	
							+ 3·35253	− 2·33514	+ 0·04289	+ 1·69894	+ 2·51237	+ 1·03727	+ 0·76756	+ 4·09062	+0·7
							− 0·00121	+ 0·00399	+ 0·06726	+ 0·02584	+ 0·02235	+ 0·01806	+ 0·04424	+ 0·25470	
									24·00576	24·94644	23·78858	28·01960	30·04470		
									− 3·72656	− 0·54994	− 0·41164	− 0·26880	− 1·61220		

*In units of 4th decimal place.

ELIMINATION 12

K_9	K_{12}	K_{14}	K_{15}	K_{17}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum—Chck*
K_9=	− 0·098736	+ 0·045121	+ 0·048506	− 0·065974	− 0·092187	+ 0·339146	− 0·208827	+ 0·289725	+ 1·128384	+ 1·195437	+ 0·865235	+ 0·224370	+ 2·670190	
5·26181	+ 0·51953	− 0·23742	− 0·25523	+ 0·34714	+ 0·48507	− 1·78452	+ 1·09881	− 1·52448	− 5·93734	− 6·29016	− 4·55270	− 1·18059	−14·05003	−0·5
	+ 3·13815	− 1·01950	− 1·10666	+ 0·11603	+ 0·16281	− 0·11089	− 0·17392	+ 4·40207	− 3·36820	− 3·45477	− 3·84560	+ 3·15841	− 1·58243	−1·1
	− 0·05132	+ 0·02344	+ 0·02520	− 0·03428	− 0·04789	+ 0·17620	− 0·10849	+ 0·15052	+ 0·58623	+ 0·62107	+ 0·44952	+ 0·11657	+ 1·38724	
		+ 4·36448	+ 1·06958	− 1·92975	− 2·19653	− 0·22416	+ 1·84655	+ 0·49540	+ 2·19352	+ 2·61968	+ 4·05742	+ 5·09595	+16·13516	+0·6
		− 0·01071	− 0·01152	+ 0·01566	+ 0·02189	− 0·08052	+ 0·04958	− 0·06879	− 0·26790	− 0·28382	− 0·20542	− 0·05327	− 0·63396	
			+ 5·22692	− 1·38230	+ 0·32765	− 1·01308	+ 0·58824	− 1·00620	+ 2·07455	+ 1·54867	+ 5·29641	+ 2·53780	+13·90620	+1·5
			− 0·01238	+ 0·01684	+ 0·02353	− 0·08656	+ 0·05330	− 0·07395	− 0·28800	− 0·30511	− 0·22085	− 0·05727	− 0·68151	
				+ 4·47379	+ 0·24965	− 0·23119	+ 0·49999	− 2·26012	− 1·05996	− 1·18714	− 2·85300	− 8·09941	−13·31620	−0·7
				− 0·02290	− 0·03200	+ 0·11773	− 0·07249	+ 0·10058	+ 0·39171	+ 0·41498	+ 0·30036	+ 0·07789	+ 0·92693	
					+ 2·74278	+ 0·45228	− 1·39401	− 0·53796	− 2·79315	− 2·77779	− 2·50508	− 0·50770	− 8·29196	−0·2
					− 0·04472	+ 0·16451	− 0·10130	+ 0·14054	+ 0·54735	+ 0·57988	+ 0·41970	+ 0·10884	+ 1·29523	
						+ 3·35132	− 2·33115	+ 1·10157	+ 1·72478	+ 2·53472	+ 1·05533	+ 0·81180	+ 4·34532	+0·7
						− 0·60521	+ 0·37266	− 0·51702	− 2·01362	− 2·13328	− 1·54403	− 0·40040	− 4·76501	
								20·27920	−24·39650	23·37694	27·75080	28·43250		
								− 0·44168	− 6·69960	− 7·51949	− 3·93916	− 0·26489		

*In units of 4th decimal place.

ELIMINATION 13

K_{15}	K_{17}	K_{14}	K_{13}	K_{18}	K_{19}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum—Check*
K_{15}=	+ 0·261856	− 0·202906	+ 0·207393	− 0·067346	+ 0·210880	− 0·123029	+ 0·207142	− 0·342609	− 0·238479	− 0·973351	− 0·475695	− 2·536120	
5·21454	− 1·36546	+ 1·05806	− 1·08146	+ 0·35118	− 1·09964	+ 0·64154	− 1·08015	+ 1·78655	+ 1·24356	+ 5·07558	+ 2·48053	+13·22469	+1·4
	+ 4·45089	− 1·91409	+ 0·08175	+ 0·21765	− 0·11346	+ 0·42750	− 2·15954	− 0·66825	− 0·77216	− 2·55264	− 8·02152	−12·38927	−0·6
	− 0·35755	+ 0·27706	− 0·28319	+ 0·09196	− 0·28795	+ 0·16799	− 0·28284	+ 0·46782	+ 0·32563	+ 1·32907	+ 0·64954	+ 3·46297	
		+ 4·35377	− 0·99606	− 2·17464	− 0·30468	+ 1·89613	+ 0·42661	+ 1·92562	+ 2·33586	+ 3·85200	+ 5·04268	+15·50120	+0·6
		− 0·21469	+ 0·21943	− 0·07126	+ 0·22312	− 0·13017	+ 0·21917	− 0·36250	− 0·25233	− 1·02986	− 0·50331	− 2·68337	
			+ 3·08683	+ 0·11492	+ 0·06531	− 0·28241	+ 4·55259	− 2·78197	− 2·83370	− 3·39608	+ 3·27498	− 0·19519	−1·1
			− 0·22429	+ 0·07283	− 0·22806	+ 0·13305	− 0·22402	+ 0·37052	+ 0·25791	+ 1·05264	+ 0·51445	+ 2·74271	
				+ 2·69806	+ 0·61679	− 1·49531	− 0·39742	− 2·24580	− 2·19791	− 2·08538	− 0·39886	− 6·99673	+0·1
				− 0·02365	+ 0·07406	− 0·04321	+ 0·07274	− 0·12032	− 0·08375	− 0·34182	− 0·16705	− 0·89063	
					+ 2·74611	− 1·95849	− 0·40687	− 0·28884	+ 0·40144	− 0·48870	+ 0·41140	− 0·41969	+0·4
					− 0·23189	+ 0·13529	− 0·22778	+ 0·37675	+ 0·26224	+ 1·07034	+ 0·52309	+ 2·78882	
							19·83752	17·69690	15·85745	23·81164	28·16761		
							− 0·22374	− 0·61209	− 0·29656	4·94032	1·17998		

*In units of 4th decimal place.

ELIMINATION 14

K_{14}	K_{17}	K_{13}	K_{18}	K_{19}	Abs. Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
K_{14}	+0·395506	+0·187633	+0·542608	+0·019705	−0·426655	−0·156020	−0·377649	−0·503380	−0·681828	−1·096710	− 3·096782	
+4·13908	−1·63703	−0·77663	−2·24590	−0·08156	+1·76596	+0·64578	+1·56312	+2·08353	+2·82214	+4·53937	+12·81783	+0·3
	+4·09334	−0·20144	+0·30961	−0·40141	+0·59549	−2·44238	−0·20043	−0·44653	−1·22357	−7·37198	− 8·92630	−0·3
	−0·64746	−0·30716	−0·88827	−0·03226	+0·69845	+0·25541	+0·61822	+0·82405	+1·11617	+1·79535	+ 5·06953	
		+2·86254	+0·18775	−0·16275	−0·14936	+4·32857	−2·41145	−2·57579	−2·34344	+3·78943	+ 2·54752	−0·9
		−0·14572	−0·42141	−0·01530	+0·33135	+0·12117	+0·29329	+0·39094	+0·52953	+0·85174	+ 2·40505	
			+2·67441	+0·69085	−1·53852	−0·32468	−2·36612	−2·28166	−2·42720	−0·56591	− 7·88736	−0·1
			−1·21864	−0·04426	+0·95822	+0·35041	+0·84816	+1·13054	+1·53132	+2·46310	+ 6·95506	
				+2·51422	−1·82320	−0·63465	+0·08791	+0·66368	+0·58164	+0·93449	+ 2·36913	+0·9
				−0·00161	+0·03480	+0·01272	+0·03080	+0·04106	+0·05561	+0·08945	+ 0·25257	
						19·61378	17·08481	15·56089	18·87132	26·98763		
						−0·10075	−0·59031	−1·04881	−1·92421	−4·97837		

*In units of 4th decimal place.

ELIMINATION 15

K_{17}	K_{13}	K_{18}	K_{19}	Abs. Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
K_{17}	+0·147597	+0·167928	+0·125852	−0·375504	+0·634662	−0·121243	−0·109557	+0·031168	+1·618347	+1·119241	
3·44588	−0·50860	−0·57866	−0·43367	+1·29394	−2·18697	+0·41779	+0·37752	−0·10740	−5·57663	−3·85677	−0·3
	+2·71682	−0·23366	−0·17805	+0·18199	+4·44974	−2·11816	−2·18485	−1·81391	+4·64117	+4·95257	−0·8
	−0·07507	−0·08541	−0·06401	+0·19098	−0·32279	+0·06166	+0·05572	−0·01585	−0·82309	−0·56925	
		+1·45577	+0·64659	−0·58030	+0·02573	−1·51796	−1·15112	−0·89588	+1·89719	−0·93230	0·0
		−0·09717	−0·07283	+0·21729	−0·36725	+0·07016	+0·06340	−0·01804	−0·93647	−0·64766	
			+2·51261	−1·78840	−0·62193	+0·11871	+0·70474	+0·63725	+1·02394	+2·62170	+0·9
			−0·05458	+0·16284	−0·27523	+0·05258	+0·04751	−0·01352	−0·70183	−0·48538	
					19·51303	16·49450	14·51208	6·94711	22·00926		
					−1·38799	−0·05065	−0·04136	−0·00335	−9·02492		

*In units of 4th decimal place.

ELIMINATION 16

K_{13}	K_{18}	K_{19}	Abs. Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
K_{13}	+0·120780	+0·091629	−0·141183	−1·562203	+0·778461	+0·805954	+0·692632	−1·445284	−1·659249	
+2·64175	−0·31907	−0·24206	+0·37297	+4·12695	−2·05650	−2·12913	−1·82976	+3·81808	+4·38332	−0·9
	+1·35860	+0·57376	−0·36301	−0·34152	−1·44780	−1·08772	−0·91392	+0·96072	−1·57996	0·0
	−0·03854	−0·02924	−0·04505	+0·49845	−0·24838	−0·25716	−0·22100	+0·46115	+0·52942	
		+2·45803	−1·62556	−0·89716	+0·17129	+0·75225	+0·62373	+0·32211	+2·13632	+0·7
		−0·02218	+0·03417	+0·37815	−0·18843	−0·19509	−0·16766	+0·34985	+0·40164	
				18·12504	16·44385	14·47072	16·94376	12·98434		
				−6·44713	−1·60091	−1·71598	−1·26735	−5·51821		

*In units of 4th decimal place.

ELIMINATION 17

K_{19}	K_{18}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
K_{19}=	−0·223544	+0·653320	+0·213071	+0·007037	−0·228733	−0·187232	−0·275863	−1·041920	
+2·43585	+0·54452	−1·59139	−0·51901	−0·01714	+0·55716	+0·45607	+0·67196	+2·53796	+0·6
	+1·32006	−0·31796	+0·15693	−1·69618	−1·34488	−1·13492	+1·42187	−1·05054	−0·2
	−0·12172	+0·35575	+0·11602	+0·00383	−0·12455	−0·10195	−0·15021	−0·56735	
			11·67791	14·84294	12·75474	15·67641	7·46613		
			−0·11059	−0·00121	−0·12744	−0·08539	−0·18537		

*In units of 4th decimal place.

ELIMINATION 18

K_{18}	Absolute Term	Side 1	Side 2	Side 3	Side 4	Side 5	Check	Sum-Check*
K_{18}=	−0·031535	−0·227773	+1·412245	+1·226221	+1·032153	−1·061185	+1·350109	
+1·19834	+0·03779	+0·27295	−1·69235	−1·46943	−1·23687	+1·27166	−1·61789	−0·2
		11·56732	14·84173	11·62730	15·59102	7·28076		
		−0·06217	−2·39001	−1·80185	−1·27664	−1·34947		

*In units of 4th decimal place.

$(ff \cdot m)$ =	11·50515	12·45172	9·82545	14·31458	5·93129
$(ff \cdot m)^{\frac{1}{3}}$ =	3·391924	3·528699	3·134549	3·783461	2·435410

REDUCED NORMAL EQUATION.

K_1	K_2	K_3	K_4	K_7	K_6	K_5	K_{10}	K_8	K_{12}
	−·251949	−·100884	+·131657	−·053968	−·047013	+·137065	+·012437	−·004207	−·007763
		+·1267523	+·2416411	+·0108013	−·0289942	+·2961985	+·0076706	+·0107450	+·0177414
			−·0189948	−·0300486	+·0012534	+·0086093	+·0043658	+·0261459	+·0050024
				−·14292333	−·35521177	+·09988093	−·00178599	−·01052539	+·01445454
					+·1648806	−·3885740	−·0053713	+·0044150	+·0550739
						−·4081947	−·0066838	+·0151765	−·0053050
							+·028122	−·010107	+·005295
								+·000054	−·008111
									+·018885

K_{11}	K_{16}	K_9	K_{15}	K_{14}	K_{17}	K_{13}	K_{19}	K_{18}
−·005554	0	−·021740	−·011511	+·003813	−·007021	+·012437	+·018532	+·008762
+·0027647	0	+·0124533	+·0280776	+·0192996	−·0174620	+·0076706	−·0392052	−·0050191
−·0212405	−·0067003	+·0151093	−·0690340	+·0691872	+·0019936	−·0023345	+·0103360	−·0433056
−·00093144	−·05277019	−·02446962	+·01281299	+·01304051	−·00985234	+·05956159	−·00568310	+·0409808
−·0436593	+·0219622	+·0296371	+·0081447	−·0027129	+·0064384	−·0295235	+·0064403	−·0188467
−·0054977	+·0505470	+·0548123	−·0129099	−·0291895	+·0235429	−·0841142	+·0044337	−·0528048
−·099505	−·023330	+·035411	+·059533	+·083176	−·065948	+·164068	+·006793	+·068573
−·034320	−·009290	+·233722	−·007299	−·204798	−·038807	+·071729	+·017395	+·023814
−·017424	+·029764	−·200723	−·079483	−·180387	+·010906	−·067520	−·284152	−·103862
−·041386	−·021586	+·046200	+·046357	+·047170	−·016904	+·019648	−·341009	+·261224
	+·014171	+·226560	+·031396	+·137792	+·063738	−·150615	−·028582	+·272085
		−·203073	−·032210	+·191635	+·364167	−·280908	+·013494	+·135992
			+·048506	+·045121	−·065974	−·098736	+·339146	−·092187
				−·202906	+·261856	+·207393	+·210880	−·067346
					+·395506	+·187633	+·019705	+·542608
						+·147597	+·125852	+·167928
							+·091629	+·120780
								−·223544

BACKWARD SOLUTION (EVALUATION OF CORRELATES).

K_1	K_2	K_3	K_4	K_7	K_6	K_5	K_{10}	K_8
+·033820	−·037502	−·031054	+·014315	−·042059	+·024705	−·024968	+·169825	−·127549
−·000276	+·000158	+·001366	−·001292	+·000594	+·001665	−·002162	−·000751	+·003275
+·012238	−·025890	+·006826	−·003753	+·004253	+·002928	+·004486	+·011487	−·187645
−·001699	−·000648	+·000197	−·005032	+·002494	+·007106	−·013861	−·006060	+·005704
+·002178	+·005416	−·000618	+·003056	−·001997	−·007302	+·020454	+·012036	−·003383
−·002171	−·010987	−·039387	−·007424	+·001544	+·016617	−·047350	+·116586	+·102690
−·000404	+·000986	−·002425	+·000450	+·000286	−·000453	+·002091	−·000256	−·002792
−·000497	+·000285	+·000345	−·000559	+·000678	+·001253	+·000810	+·005344	−·004589
0	0	+·001633	+·012862	−·005353	−·012320	+·005686	+·002264	−·007255
−·000178	+·000089	−·000681	−·000030	−·001400	−·000176	−·003190	−·001100	−·000559
+·003117	−·007123	−·002008	−·005803	−·022111	+·002130	−·002126	−·003256	−·007582
+·000966	−·002468	−·006005	+·002418	−·001014	−·003486	+·002321	−·000012	
+·003888	+·002398	+·001365	−·000558	−·001679	−·002089	+·008791		−·229685
−·006719	−·014519	−·000422	−·004896	+·019047	+·020009		+·312619	K_8
−·002378	−·001467	+·000063	−·017969	+·008341		−·049018	K_{10}	
+·002071	−·000415	+·001153	+·005485		+·050587	K_5		
−·001149	−·002110	+·000166		−·038376	K_6			
+·007010	−·008808		−·008730	K_7				
+·025851		−·069486	K_4					
	−·102605	K_3						
+·076316	K_2							
K_1								

K_{12}	K_{11}	K_{16}	K_9	K_{15}	K_{14}	K_{17}	K_{13}	K_{19}	K_{18}
−·151404	+·142170	−·044273	−·208827	−·123029	−·426655	−·375504	−·141183	+·653320	−·031535
−·008238	−·008580	−·004289	+·002907	+·002124	−·017111	−·005296	−·003809	+·007049	K_{18}
−·225192	−·018875	+·008911	+·223962	+·139259	+·013013	+·083109	+·060509		
−·001660	+·012724	+·023732	+·008342	−·017521	−·015852	−·012469		+·660369	
+·005243	−·019769	−·112950	+·020462	−·081217	−·122670		−·084483	K_{19}	
−·026853	−·078442	−·109093	−·025686	+·115509		−·310160	K_{13}		
+·001628	+·001103	−·001131	+·001704		−·569275	K_{17}			
+·001056	+·005180	−·004643		+·035125	K_{14}				
+·005261	−·003454		+·022864	K_{15}					
−·001327		−·243736	K_9						
	+·032057	K_{16}							
−·401486	K_{11}								
K_{12}									

Evaluation of Corrections to Directions

After the K's are determined by the solution of the normal equations, the v's are most conveniently evaluated by substituting their value in the correlate equations.

Column No. 1 in the correlate equation is multiplied by K_1, column No. 2 by K_2, etc. Then the algebraic sum of line 1 gives v_1, of line No. 2 gives v_2, etc.

EVALUATION OF CORRECTIONS TO DIRECTIONS

K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}
.....	+0·584848	.....	.....	−0·279403	.....	−0·115572	−0·229685	.....	.....
.....	−1·407741	.....	.....	+0·376458	.....	.....	.....	.....	.....
.....	+·0822892	.....	.....	.....	.....	+0·244455	.....	.....	.....
.....	.....	.....	.....	−0·097056	.....	−0·128943	+0·229685	.....	.....
.....	.....	.....	.....	−0·052939	.....	−0·055261	−0·229685	.....	.....
−1·269898	.....	.....	.....	.....	.....	+0·160028	.....	.....	.....
+1·543110	.....	−0·554498	.....	+0·228424	.....	.....	.....	0·022864	.....
.....	.....	+1·074948	.....	.....	.....	.....	.....	.....	.....
−0·273211	.....	−0·520450	.....	−0·175484	.....	−0·104766	+0·229685	−0·022864	.....
−0·006105	.....	+0·104229	.....	+0·003921	.....	−0·057180	−0·229685	0·022864	.....
.....	+0·280112	.....	.....	.....	.....	+0·117814	.....	.....	.....
+0·584581	−1·057858	+0·223050	+0·028023	+0·150485	.....	.....	.....	.....	.....
−0·578475	+0·777746	.....	−0·057443	.....	.....	−0·060634	+0·229685	.....	.....
.....	.....	−0·327279	+0·029420	.....	.....	.....	.....	−0·022864	.....
.....	.....	.....	.....	−0·154407	.....	.....	.....	.....	.....
.....	.....	+0·149395	+0·018770	.....	.....	.....	.....	.....	.....
.....	.....	+0·030574	.....	.....	.....	.....	.....	−0·022864	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	+0·125962	.....	.....	.....	+0·312619
.....	.....	.....	+0·00986	.....	−0·183125	.....	.....	.....	.....
.....	.....	−0·179969	−0·028634	.....	+0·057163	.....	.....	0·022864	−0·312619
.....	.....	.....	.....	.....	.....	.....	.....	0·022864	.....
.....	.....	.....	.....	.....	+0·093586	.....	.....	−0·022864	+0·312619
.....	.....	.....	.....	.....	−0·279746	.....	.....	.....	.....
.....	.....	.....	.....	.....	+0·186160	.....	.....	.....	−0·312619
.....	.....	.....	.....	−0·123035	.....	.....	.....	.....	.....
.....	.....	.....	−0·028809	.....	+0·128491	.....	.....	.....	+0·312619
.....	.....	.....	+0·022174	+0·159799	−0·166937	.....	.....	.....	.....
.....	.....	.....	+0·006635	−0·036763	+0·038446	.....	.....	.....	−0·312619
.....	.....	.....	−0·021650	−0·038724	+0·125456	.....	.....	.....	+0·312619
.....	.....	.....	+0·114712	.....	−0·316675	.....	.....	.....	.....
−0·495291	+0·665906	.....	−0·093062	.....	.....	−0·117431	−0·229685	.....	.....
+1·035608	−0·728495	.....	.....	+0·068625	+0·191219	.....	.....	.....	−0·312619
−0·540317	.....	.....	.....	.....	.....	+0·169238	.....	.....	.....
.....	+0·062589	.....	.....	−0·029901	.....	−0·051808	+0·229685	.....	.....

K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	v
+0·032057	.....	.....	.....	.....	.....	.....	.....	.....	(1) = −0·007695
.....	.....	.....	.....	.....	.....	.....	.....	+0·660369	(2) = −0·370914
−0·032057	−0·401486	.....	.....	.....	.....	.....	.....	.....	(3) = +0·633804
.....	+0·401486	.....	.....	.....	.....	.....	.....	−0·660369	(3M) = −0·255197
.....	−0·401486	.....	.....	.....	.....	.....	.....	0·660369	(4) = −0·079002
−0·032057	+0·401486	.....	.....	.....	.....	.....	−0·031535	.....	(5) = −0·771976
.....	.....	.....	.....	0·035125	.....	.....	.....	−0·660369	(6) = +0·614656
.....	.....	.....	−0·569275	−0·035125	.....	.....	0·031535	.....	(7) = +0·502083
0·032057	.....	.....	0·569275	.....	.....	.....	.....	.....	(7C) = −0·265758
−0·032057	.....	.....	−0·569275	.....	.....	.....	.....	.....	(8) = −0·763288
0·032057	+0·401486	.....	.....	.....	.....	.....	.....	.....	(9) = +0·831469
.....	.....	.....	0·569275	−0·035125	.....	−0·310160	.....	.....	(10) = +0·152271
.....	−0·401486	.....	.....	.....	.....	.....	.....	.....	(11) = −0·090607
.....	.....	.....	.....	0·035125	.....	.....	.....	.....	(12) = −0·285598
.....	.....	.....	.....	.....	.....	0·310160	.....	.....	(12H) = +0·155753
.....	.....	.....	−0·569275	0·035125	.....	0·310160	.....	.....	(13) = −0·055825
.....	.....	.....	.....	−0·035125	.....	.....	.....	0·660369	(14) = +0·632954
.....	.....	.....	.....	.....	.....	.....	.....	−0·660369	(15) = −0·660369
.....	.....	−0·084483	.....	.....	.....	.....	.....	.....	(16) = +0·354098
.....	.....	0·084483	.....	.....	0·243736	−0·310160	.....	.....	(17) = −0·155206
.....	.....	.....	0·569275	.....	−0·243736	.....	.....	.....	(18) = −0·115656
.....	.....	.....	.....	−0·035125	.....	.....	.....	.....	(19) = −0·012261
.....	.....	.....	0·569275	0·035125	.....	.....	−0·031535	.....	(20) = +0·572865
.....	.....	.....	−0·569275	.....	0·243736	.....	.....	.....	(21) = +0·057802
.....	.....	0·084483	.....	.....	−0·243736	.....	0·031535	.....	(22) = −0·497464
.....	.....	−0·084483	.....	.....	.....	.....	.....	.....	(23) = −0·210942
.....	.....	.....	.....	.....	.....	−0·310160	.....	.....	(24) = −0·433195
.....	.....	+0·084483	.....	.....	.....	.....	.....	.....	(25) = +0·496784
.....	.....	−0·084483	.....	.....	−0·243736	0·310160	.....	.....	(26) = −0·003023
.....	.....	.....	.....	.....	0·243736	.....	.....	.....	(26N) = −0·060565
.....	.....	.....	.....	.....	−0·243736	.....	.....	.....	(27) = +0·133965
.....	.....	−0·084483	.....	.....	0·243736	.....	−0·031535	.....	(28) = −0·074245
.....	+0·401486	.....	.....	.....	.....	.....	.....	.....	(29) = +0·131923
.....	.....	0·084483	.....	.....	.....	.....	.....	.....	(30) = +0·338821
0·032057	−0·401486	.....	.....	.....	.....	.....	0·031535	.....	(31) = −0·708973
−0·032057	.....	.....	.....	.....	.....	.....	.....	.....	(31R) = +0·178508

O–C Test

This test is obtained by substituting the v's in the condition equations. The sum of the v's (evaluated) in one condition should satisfy the absolute term (observed) for that particular condition.

Substitution of v's in Condition Equations

O–C TEST (OBSERVED–COMPUTED)

Absolute Term

Observed "O"	Computed "C"	O–C
− 36·90	− 36·90084	+ ·00084
+ 8·70	+ 8·69950	+ ·00050
+ 6·00	+ 5·99985	+ ·00015
− 4·20	− 4·20074	+ ·00074
+ 2·90	+ 2·89987	+ ·00013
− 6·20	− 6·20033	+ ·00033
+ 2·60	+ 2·59992	+ ·00008
+ 0·285	+ 0·285	+ ·0000
+ 0·416	+ 0·4159	+ ·0001
− 1·091	− 1·091	− ·0000
− 0·572	− 0·5720	− ·0000
+ 0·181	+ 0·1811	− ·0001
+ 0·207	+ 0·2070	+ ·0000
+ 0·603	+ 0·603	+ ·0000
+ 0·429	+ 0·429	+ ·0000
+ 0·160	+ 0·160	+ ·0000
+ 0·533	+ 0·533	+ ·0000
− 0·341	− 0·341	+ ·0000
− 0·484	− 0·4839	− ·0001

Corrections to, and Adjusted Values of Directions

The following table shows the observed directions, the v's, the adjusted directions and the probable error of a direction.

CORRECTIONS TO, AND ADJUSTED VALUES OF DIRECTIONS

No. of Direction	Observed Direction			v	v^2	Adjusted Direction		
	°	′	″	″	″	°	′	″
1	281	13	53·60	−·008	·000064	281	13	53·592
2	260	57	31·98	−.371	·137641	260	57	31·609
3	246	14	52·35	+·634	·401956	246	14	52·984
3M	214	10	50·14	−·255	·065025	214	10	49·885
4	93	18	42·33	−·079	·006241	93	18	42·251
5	37	41	48·47	−·772	·595984	37	41	47·698
6	30	29	06·45	+·615	·378225	30	29	07·065
7	15	42	38·00	+·502	·252004	15	42	38·502
7C	0	00	00·00	−·266	·070756	359	59	59·734
8	125	30	39·82	−·763	·582169	125	30	39·057
9	70	53	18·51	+·831	·690561	70	53	19·341
10	33	15	17·34	+·152	·023104	33	15	17·492
11	17	44	22·71	−·091	·008281	17	44	22·619
12	0	00	00·00	−·28560	·081567	359	59	59·71440
12H	359	32	11·96	+·15575	·024258	359	32	12·11575
13	213	28	56·45	−·056	·003136	213	28	56·394
14	156	13	22·56	+·633	·400689	156	13	23·193
15	85	49	35·12	−·660	·435600	85	49	34·460
16	0	00	00·00	+·354	·125316	0	00	00·354
17	319	42	29·55	−·155	·024025	319	42	29·395
18	257	56	28·93	−·116	·013456	257	56	28·814
19	151	05	11·54	−·01226	·000150	151	05	11·52774
20	112	18	27·84	+·573	·328329	112	18	28·413
21	48	48	01·17	+·058	·003364	48	48	01·228
22	0	00	00·00	−·407	·165649	359	59	59·593
23	330	11	42·33	−·21094	·044496	330	11	42·11906
24	110	19	25·31	−·43320	·187662	110	19	24·87680
25	109	53	42·56	+·49678	·246790	109	53	43·05678
26	70	16	02·21	−·003	·000009	70	16	02·207
26N	0	00	00·00	−·061	·003721	359	59	59·939
27	303	33	47·73	+·134	·017956	303	33	47·864
28	263	15	47·98	−·074	·005476	263	15	47·906
29	252	05	22·12	+·132	·017424	252	05	22·252
30	234	07	20·14	+·339	·114921	234	07	20·479
31	217	33	23·79	−·709	·502681	217	33	23·081
31R	160	13	13·76	+·179	·032041	160	13	13·939
					″			
				$\Sigma v^2 =$	5·990727			

Probable error of a direction $= \cdot 6745 \sqrt{\dfrac{\Sigma v^2}{\text{No. of conditions}}}$

$= 0.''379$

Distances

The lengths of triangle sides were computed through all triangles to check the accuracy of the adjustment, by first subtracting $\frac{1}{3}$ of the spherical excess of the triangle from each of the angles and using plane triangle formulæ.

The distances as computed by different routes are given below.

Line	Log Length
Rigaud–East Base	4·2871381
Rigaud–West Base	4·4009877
Newton–Rigaud	4·1241107
	4·1241108
Newton–East Base	4·2848401
	4·2848403
Newton–West Base	4·2384763
	4·2384764
Huntingdon–Newton	4·5228110
	4·5228109
Huntingdon–West Base	4·2044462
	4·2044461
Huntingdon–Rigaud	4·6015108
	4·6015111
	4·6015110
Huntingdon–East Base	4·3490386
	4·3490385
	4·3490388
Covey Hill–Huntingdon	4·5686207
	4·5686208
	4·5686206
Covey Hill–West Base	4·6824578
	4·6824578
	4·6824577
Covey Hill–East Base	4·6434239
	4·6434239
	4·6434237
Covey Hill–Rigaud	4·7938982
	4·7938981
	4·7938980
Royal–Covey Hill	4·7549412
	4·7549410
	4·7549410
Royal–Huntingdon	4·8428732
	4·8428729
	4·8428730
Royal–East Base	4·7300795
	4·7300794
	4·7300795
Royal–Rigaud	4·7462989
	4·7462990
	4·7462990

Probable Errors of Exterior Sides

The following table shows the probable error of the exterior sides as obtained by the adjustment. It will be seen that these probable errors are very small as was to be expected since the triangulation is close to the base control.

PROBABLE ERRORS OF EXTERNAL SIDES

Side	Not including Base Error	Including Base Error
Newton—Rigaud	$\frac{1}{338,034}$	$\frac{1}{335,795}$
Rigaud—Royal	$\frac{1}{324,934}$	$\frac{1}{323,206}$
Royal—Covey Hill	$\frac{1}{365,792}$	$\frac{1}{362,976}$
Covey Hill—Huntingdon	$\frac{1}{303,056}$	$\frac{1}{301,386}$
Huntingdon—Newton	$\frac{1}{470,802}$	$\frac{1}{464,684}$

Accuracy of the Triangulation

That good accuracy both in the field work and adjustment was maintained in the triangulation is indicated by the smallness of the v's on page 106, by the deduced probable error of a direction on page 106, by the probable errors of the external sides shown on page 108, by the closures of the triangles as shown below, by the closeness of the O—C test, page 105, and by the agreement of the distances as computed through different triangles, shown on page 107.

ACCURACY AS SHOWN BY ANGLE AND SIDE EQUATIONS

From Angle Equations No.	Angular Closure
	1″
8	+0·285
9	+0·416
10	−1·091
11	−0·572
12	+0·181
13	+0·207
14	+0·603
15	+0·429
16	+0·160
17	+0·533
18	−0·341
19	−0·484

Number of + closures	8
Number of − closures	4
Average angular closure	0·″442

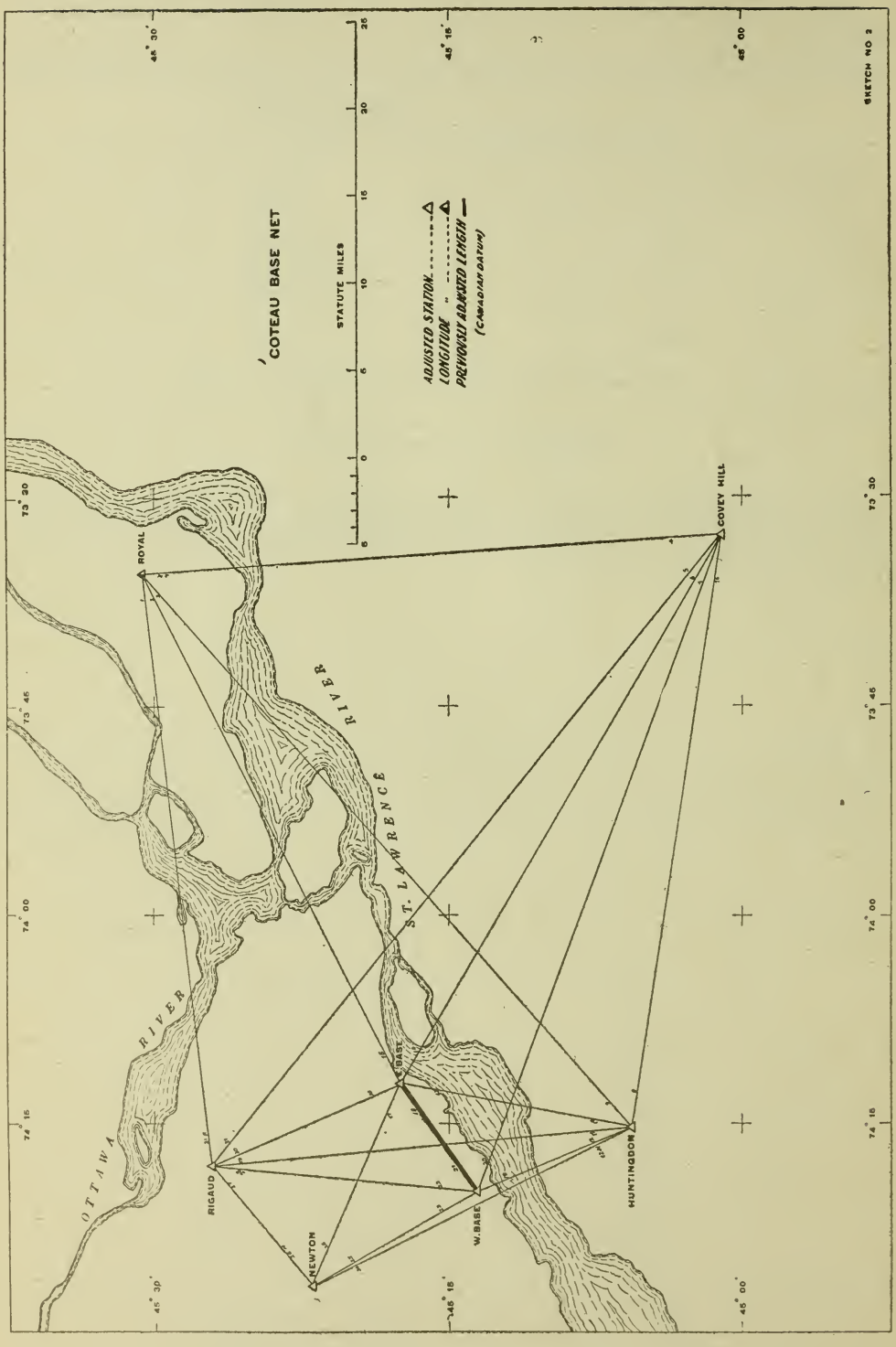
The average correction to a direction as shown by the side equations is as follows:—

From Side Equation No.	Average Correction that must ensue
	0″
1	0·445
2	0·140
3	0·132
4	0·080
5	0·072
6	0·166
7	0·072
Mean	0·158

Probable error of a direction from adjustment, 0·″379

Geographical Co-ordinates

The geographical co-ordinates were computed on a Canadian Datum which was later superseded by the North American Datum so that no list of positions will be here given. The positions on the North American Datum of the points in this net are shown on page 168.


COTEAU BASE NET
STATUTE MILES
ADJUSTED STATION
LONGITUDE
PREVIOUSLY ADJUSTED LENGTH
(CANADIAN DATUM)
SKETCH NO 2
ROYAL
COVEY HILL
RIGAUD
NEWTON
W. BASE
E. BASE
HUNTINGDON
OTTAWA RIVER
ST. LAWRENCE RIVER
45° 30'
45° 15'
45° 00'
73° 30'
73° 45'
74° 00'
74° 15'

VI

RIGAUD—STANDON NET

Introduction

This net covered the Eastern Townships in the province of Quebec from the St. Lawrence river south to the international boundary, and from Montreal on the west to Quebec.

The observing of the horizontal angles occupied parts of the seasons of 1908, 1909, and 1910, the observers being D. J. Fraser and J. L. Rannie.

As the adjusted lengths of sides and the geographical positions of stations were controlled only at the western end of the net where it joined the Coteau base net along the two lines, Rigaud–Royal and Royal–Covey Hill, and not by any base and Laplace Point, the adjustment of this net was considered only preliminary. These preliminary results have been superseded by those of two subsequent nets—the Dusable–Haldimand net, which took in the western part of this net, and the Dusable–Parke net, which comprised the eastern portion of the Rigaud–Standon net together with its extension about 100 miles north-easterly from Quebec almost as far as Rivière-du-Loup.

The net is of primary accuracy and, as the results were only preliminary, its interest lies in the methods used as well as two features which were somewhat peculiar to this net.

Interesting Features

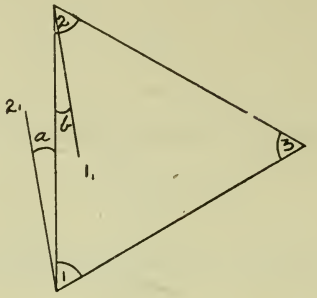
Length of Lines.—The topography of the country was of such a nature that it permitted of the use of large figures, the average length of lines being about 43 miles. This average length of lines is above the average for Eastern Canada, where the air is not so clear as in the West. It is not here claimed that the accuracy gained by having long lines was or was not economically obtained, the point being that this length of line shows a character of topography admirably adapted to triangulation.

Lateral Refraction.—The other interesting feature noted was the very clear evidence of the occurrence of horizontal refraction in connection with the observing of the horizontal angles.

Lateral refraction, or the horizontal displacement of an object due to peculiar air conditions at some point or points along the line of sight, may be called the bugbear of the observer of horizontal directions of a primary triangulation.

Although an observer's experience may teach him when this condition of the air is most likely to exist, he can never be sure that the image of his light has not been laterally displaced until the triangles are successfully closed or even sometimes until the adjustment of the triangulation shows that no large errors exist. The triangle closure is the first and easiest test he applies to find the accuracy of his work, but it sometimes happens that, in a figure whose constituent triangles have very small closing errors, the side equations will reveal large errors for which the observer is at a loss to account.

Why the triangle closure may be small and yet in error is illustrated by the following figure:—



In the triangle the angles (1), (2), (3) evidently satisfy the angle equation, but due to lateral refraction or other causes the observer at (1) in observing the direction (1–2) observes in a direction (1–2) introducing an error a, making the angle at (1) too large. Again, in observing the direction (2–1) the image of the light may appear to be in the direction (2–1) thus introducing an error b that may be equal to the error a, and which makes the angle at (2) too small.

In the triangle the angles $(1+a) + (2-b) + (3)$ also satisfy the angle equation, but these errors a and b, while not detected by the angle equation "will be detected by the side equation."

This example is shown to illustrate the importance of the side equation in testing the field work.

Sometimes, during a series of observations for the determination of the direction of a distant station, the results are seen to take a jump of several seconds, the results obtained before the jump took place having run along evenly, and those taken afterwards also running along evenly. On a repetition of the first set of positions results are obtained of about the same value as those obtained after the jump took place. The careful observer will try to obtain some observations under different conditions to corroborate those he has just made.

Sometimes, in the course of a night's work, the observer will notice a gradual, but none the less noticeable, change in the values of the individual results of a direction. Some circumstance, such as an equal change occurring in the individual results on two adjacent lines, may show him which line it is to which this gradual change may be charged.

Quite often, however, the observer will leave a station satisfied in his own mind that his results are good, only to be confronted later on by poor triangle closures. An examination of the results may point to the probability of a large error existing at this same station, and on a reoccupation of this station he may obtain a series of results equally as good as the first ones but of quite a different value to those he thought were good before.

In one figure of the Quebec triangulation south of Montreal, the triangle closures were all under one second; yet when the side equations were applied and the figure adjusted in its net, corrections to directions of as much as 1 second and corrections to angles of as much as 1.5 seconds were found to be necessary in order to compensate for some errors which were not disclosed by the closure of the triangles. An examination of the field observations by the observer failed to show any conditions which might have produced such discrepancies and the errors were laid at the door of lateral refraction as having at some unknown places and in some manner produced a deviation of the path of the ray of light passing between two stations.

An instance of a gradual change in the value of the individual results of a direction was well shown in observations made at station Kilkenny in the Quebec

triangulation in 1909. The general slope of the land in this vicinity is southeastward towards the St. Lawrence river. Three lines were observed over on October 4: Dusable, Royal, and Rigaud. The line to Dusable lay roughly northeast close to the ground a large part of its way and parallel to the St. Lawrence river, while the other two lines lay in a more southerly direction, roughly at right angles to the slope of the ground.

At the beginning of the night's observations a light wind was blowing from the southwest, gradually shifting to the northwest across the line to Dusable.

Dusable was used as the initial for the directions, the following results being obtained in the sixteen positions of the horizontal circle:—

Dusable	Royal	Rigaud	Angle Royal to Rigaud
°	° ′ ″	° ′ ″	° ′ ″
0	102 16 47·9	154 03 64·9	51 47 17·0
	45·0	60·8	15·8
	50·6	63·7	13·1
	50·8	67·4	16·6
	″	″	″
	Mean.....48·58	64·20	15·62
	48·4	65·5	17·1
	45·2	60·3	15·1
	45·5	61·4	15·9
	44·8	61·4	16·6
	″	″	″
	45·97	62·15	16·18
	45·1	62·7	17·6
	45·4	62·1	16·7
	44·3	59·3	15·0
	44·5	58·8	14·3
	″	″	″
	44·82	60·73	15·90
	42·0	59·5	17·5
	44·5	60·5	16·0
	42·8	59·2	16·4
	41·6	60·4	18·8
	″	″	″
	42·73	59·90	17·17
	″	″	″
Grand mean.....	.....45·53	61·75	16·22

It will be seen that the seconds of the directions to Royal and Rigaud showed a gradual decrease, the change in both these directions being the same in sign and almost the same in magnitude. This fact is brought out in column 4, which shows the angle Royal to Rigaud which was obtained by subtracting the direction to Royal from that to Rigaud as shown in columns 2 and 3, respectively. The individual results of this angle agree well among themselves.

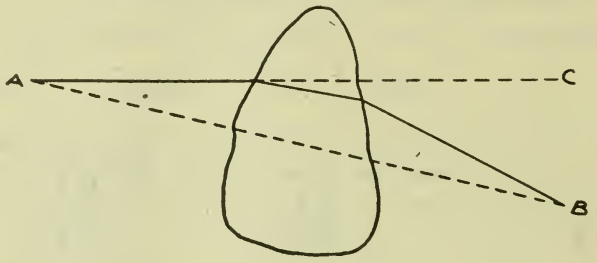
Thus it is seen that while the rays of light from Royal and Rigaud were practically constant in position, that from Dusable veered slowly to the south during the period of the night's observations.

It may be said that the angle Dusable to Royal was repeated under different atmospheric conditions. The range of the seconds of the direction to Royal in the sixteen different positions of the horizontal circle was from 44.6″ to 48.1″, with a mean value of the angle of 102° 16′ 46.72″.

Good sets of observations extending over four hours were obtained at both ends of the line in September, 1909. The error of the triangle closure was about −8.5 and subsequent observations in May and June, 1910, located an error of over −3 seconds in the angle at one end of the line and over −4 seconds

in the angle at the other end of this same line. An examination of all the data proved conclusively that this one line was " bent " to a constant amount during the whole period of observations at both ends of the line, the other lines from both stations showing practically no evidence that lateral refraction had affected their true position.

This lateral refraction is caused by unequal heating of the atmosphere along the line of sight. This unequal heating causes " pockets " of air of different densities, and the rays of light passing from one pocket to another are changed in direction and the image of the light is seen to one side of its true position.



Thus an observer at A observing a light at B sees the light in direction AC instead of direction AB.

Unequal heating of the atmosphere may no doubt have a variety of causes, more than we can attempt to explain, but a few of the more apparent may be given.

If the line of sight passes comparatively close to the ground over a variety of woods and fields a dry field heats much more quickly than a green woods during a hot day and cools more quickly at night. This will cause pockets of different densities over different parts of the line.

Wind will no doubt cause pockets of different densities through unequal heating or cooling of the air.

Many other explanations may be advanced which will fit special conditions, but no theory has ever been advanced which can give us any method of arriving at the effect of lateral refraction.

It has been noticed that on lines passing close to the ground lateral refraction is most marked, but we cannot be sure that lateral refraction does not exist even though conditions seem favourable and though the line may not pass near anything which might appear to be unfavourable to good results. At certain times on each line the atmosphere is steady enough to give good observations.

Thus it would appear that more reliable horizontal directions ought to be obtained by spreading the observations over the total time of occupation of a station. For example, more reliable results might be obtained if half the observations were made on each of two nights on six directions rather than by completing the observations on three lights each night.

The condition of lateral refraction is one which should be studied by each observer, and notes should be kept at each station regarding the direction and force of the wind, conditions along each line favourable to the occurrence of lateral refraction, and any special observations which may be noted at any time at which the results would seem to indicate any unusual movement of a light.

Other instances of this disturbing phenomenon have occurred in Canadian practice in nets the results of which have not yet been published, notably in the British Columbia net on a line observed over by H. B. Kihl. Further examples and studies on this phenomenon may be expected in the future.

Corrections to Observed Directions

As the lines were long and as the altitude of the stations was fairly great compared with the average level of the country, all observed directions were first corrected for the altitude of the station above mean sea-level and were reduced to the geodetic line by the methods explained on page 8. On the same page it is shown that these corrections are very much smaller than the probable errors of the observations, so that this practice has been discontinued except for stations at very high altitudes.

Condition Equations

The adjustment of the net was made by the conditional method, the unknowns being the most probable corrections to the observed directions.

The method of selecting the side and angle equations is that shown on page 9 of this report. It is now felt that the slight gain in accuracy does not warrant the increase in the amount of labour involved, and this method of selection of the equations is not now used.

The condition equations are here given:—

CONDITION EQUATIONS

Direction Method

1 − 2·27 (21) + 6·89 (22) − 4·62 (23) + 3·65 (24) − 2·11 (25) − 1·38 (26) + 2·99 (27) − 1·61 (28) − 4·37 (42) + 5·64 (43) − 1·27 (44) − 1·54 (54) − 0·10 = 0

2 + 4·91 (3) − 4·19 (4) − 2·65 (5) + 3·50 (6) − 0·85 (6B) − 1·98 (7) + 4·52 (8) − 2·54 (9) − 4·42 (36) + 6·61 (37) + 17·00 = 0

3 − 0·95 (10) + 4·06 (11) − 3·11 (11P) + 0·44 (12) − 0·01 (13) − 0·43 (13·0) − 3·77 (14) + 4·93 (15) − 1·16 (16) − 2·19 (19) + 6·36 (20) − 4·17 (21) − 2·62 (44) + 3·82 (45) − 1·20 (46) + 0·60 = 0

4 − 2·67 (28) + 5·27 (29) − 2·60 (29D) − 0·83 (30) + 3·98 (31) − 3·15 (32) − 2·63 (33) + 3·17 (34) − 0·54 (35) − 3·39 (40) + 6·50 (41) − 3·11 (42) + 3·80 = 0

5 − 2·58 (9) + 3·53 (10) − 0·95 (11) − 4·17 (20) + 6·44 (21) − 2·27 (22) − 1·61 (27) + 4·28 (28) − 2·67 (29) − 0·54 (34) + 4·12 (35) − 3·58 (36) − 1·53 (47) + 0·57 (48) + 0·96 (49) + 0·20 = 0

6 + 1·37 (53) + 4·02 (61) − 7·17 (62) + 3·15 (62L) − 4·07 (63) + 0·95 (63M) + 3·12 (64) + 2·01 (65) − 3·38 (66) + 1·60 (70) − 3·89 (71) + 2·29 (72) + 0·40 = 0

7 − 1·58 (18) − 1·54 (24) − 1·27 (43) + 3·89 (44) − 2·62 (45) + 0·96 (48) + 1·70 (49) − 2·66 (50) + 6·20 (54) − 4·66 (55) − 3·12 (63) + 4·70 (64) − 0·31 (67) − 2·29 (71) + 2·60 (72) − 5·20 = 0

8 − 0·60 (23) + 1·97 (53) − 4·66 (54) + 6·85 (55) − 2·19 (55C) − 0·48 (56) + 1·52 (57) − 1·04 (57B) − 1·45 (58) + 2·75 (59) − 1·30 (59S) − 1·29 (60) + 5·31 (61) − 4·02 (62) − 1·37 (66) + 1·20 = 0

9 + 6·01 (2) − 3·51 (3) − 2·54 (8) + 5·12 (9) − 2·58 (10) − 3·58 (35) + 4·38 (36) + 3·26 (39) − 2·50 (40) −0·76 (46) − 9·90 = 0

10 − 1·16 (15) + 3·30 (16) − 2·14 (16H) − 2·74 (17) + 4·32 (18) + 4·32 (19) − 2·19 (20) − 2·66 (49) + 5·48 (50) − 2·82 (51) − 1·58 (64) − 2·13 (65) − 0·40 = 0

11 − 1·80 (1) − 2·50 (2) − 3·15 (31) + 4·81 (32) − 1·66 (32K) − 2·50 (39) + 5·89 (40) 3·39 (41) − 3·90 = 0

12 − (15) + (16H) − (17) + (20) − (49) + (51) + (64) − (65) − 2·764 = 0

13 − (28) + (29D) − (30) + (32) − (33) + (35) − (40) + (42) − 2·034 = 0

14 − (21) + (23) + (25) − (26) + (28) − (42) + (44) − (54) + ·539 = 0

15 − (53) + (61) − (62L) + (63M) − (64) + (65) − (70) + (72) + 1·550 = 0

16 − (16) + (16H) − (17) + (18) + (19) − (20) + (49) − (50) + 0·655 = 0

17 − (15) + (16) + (18) − (19) − (50) + (51) − (64) + (65) − 0·033 = 0

18 − (29) + (29D) − (30) + (31) + (34) − (35) + (40) − (41) − 3·679 = 0

19 − (28) + (29) + (31) − (32) + (33) − (34) − (41) + (42) − 1·021 = 0

20 − (21) + (22) + (24) − (25) + (26) − (27) − (43) + (44) + 2·375 = 0

21 − (22) + (23) + (24) + (27) − (28) + (42) − (43) − (54) − 1·564 = 0

22 − (2) + (3) − (8) + (9) + (35) − (36) + (39) − (40) + 0·848 = 0

23 + (53) + (62) − (62L) − (63) + (63M) − (66) + (71) − (72) + 0·838 = 0

24 + (61) − (62) − (63) + (64) − (65) + (66) − (70) + (71) − 0·567 = 0

25 + (3) − (8) + (10) − (35) + (40) − (46) − ·699 = 0

26 + (4) − (5) + (6B) − (7) + (9) − (36) − ·641 = 0

27 + (3) + (6) − (6B) + (7) − (8) − (37) + ·536 = 0

28 + (2) + (9) − (10) − (36) − (39) + (46) + ·717 = 0

29 − (10) + (11) − (45) + (46) − (47) + (48) + 1·664 = 0

30 − (20) + (21) − (44) + (45) − (48) + (49) − 1·326 = 0
31 − (13) + (13 O) − (14) + (15) − (51) + (52) − 2·542 = 0
32 − (11) + (11P) − (12) + (13) + (47) − (52) + 1·966 = 0
33 + (59) − (59S) + (60) − (61) − (69) + (70) − 3·022 = 0
34 − (23) + (53) + (54) − (55) + (67) − (72) + 1·619 = 0
35 + (55) − (55C) + (56) − (57) − (67) + (68) − 1·057 = 0
36 (57) − (57B) + (58) − (59) − (68) + (69) + 0·056 = 0
37 − (1) − (32) + (32K) + (33) − 0·767 = 0

Correlate Equations and Equations for the Reciprocal of Weights of the Exterior Sides

The correlate equations were formed in the usual manner, and at their right-hand side were placed in vertical columns equations for finding the weights and hence the probable errors of the external sides of the net. The method of forming these equations and of evaluating the probable errors of these sides is shown on page 81, a practical example of the solution being shown in the case of the Coteau Base net, page 103.

Normal Equations and Corrections to Directions

The normal equations were formed as usual and were solved by the substitution method, the resulting values of the correlates being substituted in the correlate equations to obtain the corrections to the directions which are shown below.

CORRECTIONS TO DIRECTIONS

Number of Direction	Correction	Number of Direction	Correction	Number of Direction	Correction
	"		"		"
1	− ·707	29D	+ ·664	59	+ ·505
2	+ ·195	30	− ·893	59S	− ·706
3	− ·930	31	+ ·451	60	+ ·525
4	+ ·459	32	+ ·226	61	− ·519
5	+ ·079	32K	+ ·217	62	+ ·187
6	− ·319	33	+ ·070	62L	− ·192
6B	+ ·240	34	+ ·448	63	− ·178
7	− ·017	35	− ·045	63M	− ·128
8	− ·494	36	+ ·520	64	+ ·868
9	+ ·523	37	− ·477	65	− ·603
10	+ ·349	38	.....	66	+ ·256
11	− ·129	39	+ ·141	67	− ·503
11P	− ·232	40	+ ·317	68	− ·038
12	+ ·195	41	− ·677	69	− ·312
13	− ·810	42	+ ·092	70	+ ·455
13O	+ ·614	43	+ ·185	71	− ·179
14	− ·672	44	+ ·060	72	+ ·577
15	− ·247	45	+ ·308		
16	+ ·712	46	− ·425	Σv_2 =	15·03968
16H	+ ·207	47	− ·048		
17	− ·449	48	− ·502		
18	− ·113	49	− ·210		
19	− ·378	50	− ·165		
20	+ ·063	51	+ ·116		
21	+ ·850	52	+ ·810		
22	− ·143	53	− ·254		
23	+ ·211	54	+ ·013		
24	+ ·102	55	+ ·087		
25	+ ·218	55C	− ·419		
26	− ·516	56	+ ·231		
27	+ ·625	57	+ ·145		
28	− ·589	57B	− ·376		
29	− ·184	58	+ ·201		

Probable Error of a Direction

The probable error of a direction is found by the following equation:—

$$\text{p. e.} = \cdot 6745 \sqrt{\frac{\Sigma v_2}{\text{Number of Conditions}}}$$

$$= \cdot 6745 \sqrt{\frac{15 \cdot 03968}{37}}$$

$$= \pm 0'' \cdot 430$$

O − C Test

A good test of the accuracy of the adjustment is obtained by substituting the values of the v's in the condition equations. If the v's have been correctly determined they should satisfy these equations exactly and the absolute term of the condition equations O (observed) should equal the sum of the v terms in that equation, C (evaluated).

In this net the O − C test shows that the adjustment was accurately done.

CONDITION EQUATIONS O-C

No.	Absolute Term		
	Observed "O"	Computed "C"	O–C
1	+ 0·10	+ 0·10014	− ·00014
2	−17·00	−17·000015	+ ·000015
3	− 0·60	− 0·59992	− ·00008
4	− 3·80	− 3·80000	·0
5	− 0·20	− 0·19995	− ·00005
6	− 0·40	− 0·39884	− ·00116
7	+ 5·20	+ 5·19874	+ ·00126
8	− 1·20	− 1·19860	− ·00140
9	+ 9·90	+ 9·90005	− ·00005
10	+ 0·40	+ 0·40002	− ·00002
11	+ 3·90	+ 3·89995	− ·00005
12	+ 2·764	+ 2·76392	+ ·00008
13	+ 2·034	+ 2·03395	+ ·00005
14	− 0·539	− 0·53896	− ·00004
15	− 1·550	− 1·54997	− ·00003
16	− 0·655	− 0·65504	+ ·00004
17	+ 0·033	+ 0·03308	− ·00008
18	+ 3·679	+ 3·67903	− ·00003
19	+ 1·021	+ 1·02102	− ·00002
20	+ 2·375	+ 2·37504	− ·00004
21	+ 1·564	+ 1·56406	− ·00006
22	− 0·848	− 0·84801	+ ·00001
23	− 0·838	− 0·83808	+ ·00008
24	+ 0·567	+ 0·56701	− ·00001
25	+ 0·699	+ 0·69903	− ·00003
26	+ 0·641	+ 0·64101	− ·00001
27	− 0·536	− 0·53594	− ·00006
28	− 0·717	− 0·71698	− ·00002
29	− 1·664	− 1·66403	+ ·00003
30	+ 1·326	+ 1·32605	− ·00005
31	+ 2·542	+ 2·54194	+ ·00006
32	− 1·966	− 1·96599	− ·00001
33	+ 3·022	+ 3·02191	+ ·00009
34	− 1·619	− 1·61912	+ ·00012
35	+ 1·057	+ 1·05709	− ·00009
36	− 0·056	− 0·05592	− ·00008
37	+ 0·767	+ 0·76699	+ ·00001

Distances

Another test of the accuracy of the adjustment is found by the closeness of the agreement of the lengths of triangle sides as computed through different triangles. In this operation we first subtract one-third of the spherical excess of the triangle from each angle and use plane triangle formulæ for obtaining the lengths of sides.

The distances as evaluated by the different routes, are given below and show good agreement:—

COMPARISON OF COMPUTED LENGTHS

Line	Log Length	Line	Log Length
Royal–Yamaska	4·7542380 4·7542381	Dusable–Carmel	4·7367492 4·7367492
Covey Hill–Yamaska	4·9391470 4·9391471	Orford–Hereford	4·7515332 4·7515330
Kilkenny–Yamaska	4·9688056 4·9688055	Owl's Head–Hereford	4·7398416 4·7398418
Royal–Dusable	4·9224813 4·9224812	Ham–Hereford	4·8964981 4·8964979
Kilkenny–Dusable	4·7284561 4·7284562	Orford–Megantic	4·9499721 4·9499719
Yamaska–Dusable	4·9482323 4·9482322	Hereford-Megantic	4·7435018 4·7435015
Royal–St. Armand	4·9254933 4·9254931	Ham–Megantic	4·7429088 4·7429086
Covey Hill–St. Armand	4·9207146 4·9207144	Ham–Thetford	4·6603560 4·6603563
Yamaska–St. Armand	4·6586243 4·6586241	Megantic–Thetford	4·9004518 4·9004515
Royal–Bellevue	4·9574255 4·9574257	Carmel–Thetford	5·0288926 5·0288929
St. Armand–Bellevue	4·5915820 4·5915818	Ham–Liniere	4·9917723 4·9917722
Covey Hill–Bellevue	4·8017838 4·8017840	Thetford–Liniere	4·9171231 4·9171230
Yamaska–Ham	5·0158634 5·0158632	Megantic–Liniere	4·8579950 4·8579949
Orford–Ham	4·8534354 4·8534357	Thetford–Belair	4·8807421 4·8807420
Dusable–Ham	5·1138485 5·1138482	Standon–Belair	4·9055565 4·9055564
Yamaska–Carmel	5·0741018 5·0741018	Carmel–Belair	4·9731724 4·9731725
Ham–Carmel	5·0413757 5·0413757		

Probable Errors of External Sides

The probable errors of the lengths of the external sides of this net, including the probable error of the Coteau Base, as computed by the adjustment of the nets, were found to be as follows:—

Rigaud–Kilkenny	1/337,838
Kilkenny–Dusable	1/211,730
Dusable–Carmel	1/181,481
Carmel–Belair	1/275,330
Belair–Standon	1/236,630
Standon–Liniere	1/251,572
Liniere–Megantic	1/225,581
Megantic–Hereford	1/214,638
Hereford–Owl's Head	1/210,837
Owl's Head–St. Armand	1/158,378
St. Armand–Bellevue	1/183,823
Bellevue–Covey Hill	1/290,276

It will be noticed that the probable errors of the sides, Dusable–Carmel, Owl's head–St. Armand, and St. Armand–Bellevue are larger than those of the other sides, notwithstanding the fact that these three lines are closer to the base than others shown above. The explanation, of course, is that the triangles through which the computation of distances has to go to reach these sides with large probable errors are poorer in shape, that is, have smaller angles, than those which are used in the computation of some of the sides a greater distance away from the base.

ACCURACY AS SHOWN BY ANGLE AND SIDE EQUATIONS

From Angle Equation No.	Angular Closure
12	− 2·764
13	− 2·034
14	+ 0·539
15	+ 1·550
16	+ 0·655
17	− 0·033
18	− 3·679
19	− 1·021
20	+ 2·375
21	− 1·564
22	+ 0·848
23	+ 0·838
24	− 0·567
25	− 0·699
26	− 0·641
27	+ 0·536
28	+ 0·717
29	+ 1·664
30	− 1·326
31	− 2·542
32	+ 1·966
33	− 3·022
34	+ 1·619
35	− 1·057
36	+ 0·056
37	− 0·767

Number of + *ve* closures	12
Number of − *ve* closures	14
Average angular closure	1·″349

The average correction to a direction as shown by the side equations is as follows:—

From Side Equation No.	Average Correction that must ensue
	″
1	·003
2	·470
3	·015
4	·100
5	·005
6	·010
7	·129
8	·033
9	·289
10	·011
11	·152
Mean	·111

Probable Error of a direction from adjustment = 0″·430

Here equation 2 shows that large errors existed in the observing which were not indicated by the closure of the triangles in angle equations 22, 25, 26, 27 and 28 above.

Accuracy of the Triangulation

The accuracy both of the field work and the adjustment is shown to be good by the smallness of the *v*'s on page 117, by the agreement in the O−C test on page 118, by the deduced probable error of a direction shown on page 118, by the agreement of the distances as computed through different triangles as shown on page 119, by the smallness of the probable errors of the external sides shown on page 120 and by the angular closures and side equation tests shown on page 120.

Geographical Co-ordinates

No list of geographical co-ordinates is given as they will be found with the description of the Dusable–Haldimand and the Dusable–Parke nets.

In the present case the co-ordinates were determined by means of three expansional formulæ of Helmert, which were adapted to the use of multiplying machines for getting the different terms of the expansions.

VII

RIGAUD—NORTH MOUNTAIN NET

Introduction

This geodetic net joins the Coteau base net at Rigaud, Huntingdon and Newton, the lines Rigaud–Newton and Newton–Huntingdon being the base, and extends westward to King Mountain, covering the region between the Ottawa and St. Lawrence rivers.

The field work and the adjustment are of primary accuracy. The positions were computed on the Canadian datum, based on the observed latitude and azimuth at Vankleek and the longitude of Royal as given by the United States Coast and Geodetic Survey. As the Canadian datum has been superseded by the North American datum, and as this net was afterwards included in the Dusable–Haldimand net, the results of this adjustment are not published, but the methods used are of historic value, and for this reason the adjustment is included in this report.

Weights

The usual procedure of giving unit weight to each direction was followed with one exception, that of the direction Maxville–Huntingdon. Owing to weather conditions at the end of the observing season, this direction was observed in eleven positions only instead of the usual sixteen positions. For this reason the weight eleven-sixteenths was given to this direction to illustrate the method of dealing with weighted observations.

Preliminary Corrections to Observed Directions

All observed directions were corrected for the altitude of the station observed on and reduced to the geodetic line. As these corrections are very small where the elevations are not great and lines not long, this practice has since been discontinued, except in cases of high altitudes and very long lines.

Selection of Angle and Side Equations

The angle equations of quadrilaterals were picked out according to the plan given in Jordan (Handbuck der Vermessungskunde, vol. I pp. 249–250). An illustration of this method for the quadrilateral Maxville–Alexandria–Huntingdon–Bonville is shown on page 144.

The side equations of quadrilaterals were formed by taking the pole at the intersection of the diagonals. This method introduces all the angles of the quadrilateral into the side equations, while with the pole at one of the angular points, the angles at that point are left out.

These methods of forming angle and side equations give best results, but as they entail more work they have been discontinued in favour of using the closure of three of the triangles for the three-angle equations, and taking the pole at the angular point having the triangle with greatest area opposite; this pole introduces a greater number of smaller angles than a pole at any of the other angular points. The decrease in the amount of work in using these latter methods of forming the condition equations more than compensates for any slight increase in the probable error.

The following table shows the condition equations for the net:—

FIGURE RIGAUD–NORTH MOUNTAIN

CONDITION EQUATIONS

(Direction Method)

1. $-1\cdot74\ (1) + 21\cdot73\ (3) + 0\cdot39\ (4) - 0\cdot65\ (5) - 28\cdot94\ (9) + 30\cdot20\ (10) - 1\cdot26\ (11) - 4\cdot20\ (26) + 6\cdot39\ (27) - 2\cdot19\ (28) - 66\cdot60 = 0$ $\quad \Sigma = 2290\cdot2145$
2. $16\cdot64\ (6) - 21\cdot72\ (7) + 5\cdot08\ (7H) - 0\cdot41\ (8) + 1\cdot50\ (12) - 1\cdot09\ (13) + 1\cdot81\ (14) - 4\cdot32\ (15) + 2\cdot51\ (16) - 7\cdot60\ (18) + 6\cdot76\ (19) + 0\cdot84\ (25) - 8\cdot50 = 0$ $\quad \Sigma = 910\cdot4624$
3. $-3\cdot04\ (34) + 1\cdot31\ (35) + 1\cdot72\ (35B) + 0\cdot38\ (36) - 4\cdot88\ (37) + 4\cdot50\ (41) - 11\cdot19\ (50) + 16\cdot14\ (51) - 4\cdot95\ (52) - 18\cdot60 = 0$ $\quad \Sigma = 468\cdot3431$
4. $2\cdot91\ (1) - 11\cdot03\ (2) + 8\cdot12\ (3) + 1\cdot26\ (10) - 1\cdot89\ (11) + 0\cdot63\ (12) + 3\cdot25\ (19) - 5\cdot68\ (20) + 2\cdot44\ (21) + 0\cdot75\ (26) - 4\cdot01\ (28) + 3\cdot27\ (29) - 0\cdot80 = 0$ $\quad \Sigma = 277\cdot7340$
5. $4\cdot65\ (39) - 0\cdot85\ (40) - 3\cdot81\ (41) + 1\cdot89\ (46) - 1\cdot68\ (47) - 0\cdot21\ (47M) + 2\cdot68\ (48) - 10\cdot73\ (49) + 8\cdot05\ (50) + 5\cdot20 = 0$ $\quad \Sigma = 230\cdot4175$
6. $3\cdot45\ (22) - 5\cdot46\ (23) + 2\cdot02\ (24) + 3\cdot13\ (31) - 3\cdot49\ (32) + 0\cdot35\ (33) + 3\cdot09\ (37) - 8\cdot95\ (38) + 5\cdot86\ (39) + 0\cdot83\ (43) - 2\cdot90\ (44) + 2\cdot07\ (45) + 13\cdot80 = 0$ $\quad \Sigma = 205\cdot2680$
7. $-1\cdot74\ (1) + 3\cdot08\ (3) + 5\cdot43\ (6) - 3\cdot69\ (7H) - 1\cdot81\ (14) + 4\cdot32\ (15) - 2\cdot51\ (16) + 0\cdot78\ (19) - 0\cdot61\ (21) - 0\cdot17\ (25) - 0\cdot75\ (26) + 4\cdot01\ (28) - 3\cdot27\ (29) + 10\cdot50 = 0$ $\quad \Sigma = 112\cdot1985$
8. $0\cdot63\ (11) - 2\cdot13\ (12) + 1\cdot50\ (13) + 2\cdot51\ (15) - 3\cdot82\ (16) + 1\cdot31\ (17) + 3\cdot27\ (28) - 4\cdot36\ (29) + 1\cdot09\ (29V) + 1\cdot64\ (30) - 4\cdot77\ (31) + 3\cdot13\ (32) + 1\cdot02\ (42) - 1\cdot85\ (43) + 0\cdot83\ (44) - 1\cdot20 = 0$ $\quad \Sigma = 101\cdot0742$
9. $-0\cdot35\ (32) + 2\cdot69\ (33) - 2\cdot33\ (33P) - 1\cdot31\ (34) + 2\cdot03\ (35) - 0\cdot71\ (35B) - 2\cdot07\ (44) + 3\cdot26\ (45) - 1\cdot19\ (45R) - 1\cdot68\ (46) + 3\cdot84\ (47) - 2\cdot16\ (47M) - 1\cdot60\ (48) + 4\cdot76\ (50) - 3\cdot16\ (52) - 2\cdot80 = 0$ $\quad \Sigma = 92\cdot8940$
10. $1\cdot40\ (1) + 3\cdot33\ (6) + 0\cdot86\ (8) - 1\cdot92\ (9) + 1\cdot06\ (11) + 4\cdot20\ (26) - 6\cdot39\ (27) + 2\cdot19\ (28) + 10\cdot00 = 0$ $\quad \Sigma = 81\cdot8667$
11. $-(6) + (7) + (8) - (13) + (15) - (16) - (18) + (25) + 1\cdot132 = 0$ $\quad \Sigma = 8$
12. $(7) - (7H) - (12) + (13) + (14) - (15) - (18) + (19) + 3\cdot295 = 0$ $\quad \Sigma = 8$
13. $(6) - (7H) - (8) + (12) + (14) - (16) - (19) + (25) + 0\cdot255 = 0$ $\quad \Sigma = 8$
14. $(1) - (2) - (11) + (12) - (19) + (20) - (26) + (28) + 1\cdot459 = 0$ $\quad \Sigma = 8$
15. $(2) - (3) + (10) - (11) - (20) + (21) + (28) - (29) + 0\cdot317 = 0$ $\quad \Sigma = 8$
16. $(1) - (3) + (10) - (12) + (19) - (21) - (26) + 29) - 1\cdot288 = 0$ $\quad \Sigma = 8$
17. $(23) - (24) + (32) - (33) + (37) - (38) + (43) - (44) - 0\cdot080 = 0$ $\quad \Sigma = 8$
18. $(22) - (23) - (31) + (32) + (38) - (39) - (44) + (45) - 0\cdot203 = 0$ $\quad \Sigma = 8$
19. $(22) - (24) - (31) + (33) - (37) + (39) + (43) - (45) + 1\cdot357 = 0$ $\quad \Sigma = 8$
20. $(3) - (4) - (10) + (11) + (27) - (28) + 0\cdot202 = 0$ $\quad \Sigma = 6$
21. $(1) - (5) + (9) - (11) - (26) + (28) + 0\cdot705 = 0$ $\quad \Sigma = 6$
22. $(16) - (17) + (24) - (25) + (42) - (43) + 0\cdot057 = 0$ $\quad \Sigma = 6$
23. $(21) - (22) - (29) + (29V) - (30) + (31) + 0\cdot688 = 0$ $\quad \Sigma = 6$
24. $-(33) + (33P) - (34) + (35) - (36) + (37) - 1\cdot644 = 0$ $\quad \Sigma = 6$
25. $(35) + (35B) + (36) - (41) + (50) - (52) + 0\cdot024 = 0$ $\quad \Sigma = 6$
26. $-(40) + (41) + (47) - (47M) + (48) - (50) + 0\cdot533 = 0$ $\quad \Sigma = 6$
27. $(39) + (40) + (45) - (45R) + (46) - (47) - 0\cdot153 = 0$ $\quad \Sigma = 6$
28. $(5) - (6) + (8) - (9) + 0\cdot731 = 0$ $\quad \Sigma = 4$

Formation of Equations for the Reciprocal of Weights of Exterior Sides

The following is the formation of equations for the weight of exterior sides. These equations are included in the correlate equations in the same manner as the condition equations.

Side 8 = Bonville – Huntingdon

$$S_8 = b_2 \frac{\sin(13-8)\sin(5-4)}{\sin(14-15)\sin(8-9)}$$

+Angle		C.D.	−Angle		C.D.
13 − 8	= 100° 57′ 50·98″.....	−0·408	14 − 15	=	1·810
5 − H	=	0·377	8 − 9	=	0·856

$$\therefore d\log S_8 = 0{\cdot}38\,(5) - 0{\cdot}45\,(8) + 0{\cdot}86\,(9) - 0{\cdot}41\,(13) - 1{\cdot}81\,(14) + 1{\cdot}81\,(15)$$

Side 7 = Roxboro–Bonville

$$S_7 = b_2 \frac{\sin(24-25)\sin(12-13)\sin(6-7H)\sin(5-H)}{\sin(42-43)\sin(25-19)\sin(14-15)\sin(8-9)}$$

+Angle		C.D.	−Angle		C.D.
24 − 25	= 57° 44′ 44·84″.....	1·329	42 − 43	.....	1·017
12 − 13	= 54° 31′ 05·48″.....	1·500	25 − 19	.....	0·167
6 − 7H	= 29° 43′ 38·76″.....	3·688	14 − 15	.....	1·810
5 − H	= 79° 50′ 58·873″.....	0·377	8 − 9	.....	0·856

$$\therefore d\log S_7 = 0{\cdot}38\,(5) + 3{\cdot}69\,(6) - 3{\cdot}69\,(7H) - 0{\cdot}86\,(8) + 0{\cdot}86\,(9) + 1{\cdot}50\,(12) - 1{\cdot}50\,(13) - 1{\cdot}81\,(14) + 1{\cdot}81\,(15) + 0{\cdot}17\,(19) + 1{\cdot}33\,(24) - 1{\cdot}50\,(25) - 1{\cdot}02\,(42) + 1{\cdot}02\,(43)$$

Side 6 = North Mountain-Roxboro

$$S_6 = b_2 \frac{\sin(40-39)\sin(33-32)\sin(22-24)\sin(29V-29)\sin(11-12)\sin(4-5)\sin(N-6)}{\sin(46-47)\sin(39-37)\sin(43-44)\sin(31-30)\sin(19-21)\sin(28-27)\sin(8-9)}$$

+Angle		C.D.	−Angle		C.D.
40 − 39	= 68° 06′ 50·99″.....	0·846	46 − 47	=	1·681
33 − 32	=	0·355	39 − 37	=	1·527
22 − 24	=	0·461	43 − 44	=	0·830
29V − 29	=	1·093	31 − 30	=	1·641
11 − 12	=	0·627	19 − 21	=	0·611
4 − 5	=	0·648	28 − 27	=	2·190
N − 6	=	3·334	8 − 9	=	0·856

$$\therefore d\log S_6 = 0{\cdot}65\,(4) - 0{\cdot}65\,(5) - 3{\cdot}33\,(6) - 0{\cdot}86\,(8) + 0{\cdot}86\,(9) + 0{\cdot}63\,(11) - 0{\cdot}63\,(12) - 0{\cdot}61\,(19 + 0{\cdot}61\,(21) + 0{\cdot}46\,(22) - 0{\cdot}46\,(24) + 2{\cdot}19\,(27) - 2{\cdot}19\,(28) - 1{\cdot}09\,(29) + 1{\cdot}09\,(29V) + 1{\cdot}64\,(30) - 1{\cdot}64\,(31) - 0{\cdot}35\,(32) + 0{\cdot}35\,(33) + 1{\cdot}53\,(37) - 2{\cdot}37\,(39) + 0{\cdot}85\,(40) - 0{\cdot}83\,(43) + 0{\cdot}83\,(44) - 1{\cdot}68\,(46) + 1{\cdot}68\,(47)$$

FORMATION OF EQUATIONS FOR WEIGHTS OF EXTERIOR SIDES—*Continued*

Side 5 = King Mountain–North Mountain

$$S_5 = b_2 \frac{\sin(41-40)\sin(45-45R)\sin(33-32)\sin(22-24)\sin(29V-29)\sin(11-12)\sin(4-5)\sin(N-6)}{\sin(48-50)\sin(46-47)\sin(39-37)\sin(43-44)\sin(31-30)\sin(19-21)\sin(28-27)\sin(8-9)}$$

+Angle		C.D.	−Angle		C.D.
41 − 40	= 82° 55′ 56·63″	0·261	48 − 50	=	1·597
45 − 45R	= 60° 29′ 21·28″	1·192	46 − 47	=	1·681
33 − 32	=	0·355	39 − 37	=	1·527
22 − 24	=	0·461	43 − 44	=	0·830
29V − 29	=	1·093	31 − 30	=	1·641
11 − 12	=	0·627	19 − 21	=	0·611
4 − 5	=	0·648	28 − 27	=	2·190
N − 6	=	3·334	8 − 9	=	0·856

$$\therefore d\log S_5 = \begin{aligned} &0{\cdot}65\,(4) - 0{\cdot}65\,(5) - 3{\cdot}33\,(6) - 0{\cdot}86\,(8) + 0{\cdot}86\,(9) + 0{\cdot}63\,(11) \\ &- 0{\cdot}63\,(12) - 0{\cdot}61\,(19) + 0{\cdot}61\,(21) + 0{\cdot}46\,(22) - 0{\cdot}46\,(24) + 2{\cdot}19\,(27) \\ &- 2{\cdot}19\,(28) - 1{\cdot}09\,(29) + 1{\cdot}09\,(29V) + 1{\cdot}64\,(30) - 1{\cdot}64\,(31) - 0{\cdot}35\,(32) \\ &+ 0{\cdot}35\,(33) + 1{\cdot}53\,(37) - 1{\cdot}53\,(39) - 0{\cdot}26\,(40) + 0{\cdot}26\,(41) - 0{\cdot}83\,(43) \\ &+ 0{\cdot}83\,(44) + 1{\cdot}19\,(45) - 1{\cdot}19\,(45R) - 1{\cdot}68\,(46) + 1{\cdot}68\,(47) - 1{\cdot}60\,(48) \\ &+ 1{\cdot}60\,(50) \end{aligned}$$

Side 4 = Buckingham–King Mountain

$$S_4 = b_2 \frac{\sin(36-41)\sin(47-47M)\sin(45-45R)\sin(33-32)\sin(22-24)\sin(29V-29)\sin(11-12)\sin(4-5)\sin(N-6)}{\sin(35B-35)\sin(48-50)\sin(46-47)\sin(39-37)\sin(43-44)\sin(31-30)\sin(19-21)\sin(28-27)\sin(8-9)}$$

+Angle		C.D.	−Angle		C.D.
36 − 41	= 75° 01′ 47·41″	0·563	35B − 35	= 71° 16′ 34·59″	0·714
47 − 47M	= 44° 14′ 57·79″	2·162	48 − 50	= 52° 49′ 10·09″	1·597
45 − 45R	= 60° 29′ 21·38″	1·192	46 − 47	= 51° 23′ 51·27″	1·681
33 − 32	= 80° 25′ 57·31″	0·355	39 − 37	= 54° 02′ 01·75″	1·527
22 − 24	=	0·461	43 − 44	=	0·830
29V − 29	=	1·093	31 − 30	=	1·641
11 − 12	=	0·627	19 − 21	=	0·611
4 − 5	=	0·648	28 − 27	=	2·190
N − 6	=	3·334	8 − 9	=	0·856

$$\therefore d\log S_4 = \begin{aligned} &0{\cdot}65\,(4) - 0{\cdot}65\,(5) - 3{\cdot}33\,(6) - 0{\cdot}86\,(8) + 0{\cdot}86\,(9) + 0{\cdot}63\,(11) \\ &- 0{\cdot}63\,(12) - 0{\cdot}61\,(19) + 0{\cdot}61\,(21) + 0{\cdot}46\,(22) - 0{\cdot}46\,(24) + 2{\cdot}19\,(27) \\ &- 2{\cdot}19\,(28) - 1{\cdot}09\,(29) + 1{\cdot}09\,(29V) + 1{\cdot}64\,(30) - 1{\cdot}64\,(31) - 0{\cdot}35\,(32) \\ &+ 0{\cdot}35\,(33) + 0{\cdot}71\,(35) - 0{\cdot}71\,(35B) + 0{\cdot}56\,(36) + 1{\cdot}53\,(37) - 1{\cdot}53\,(39) \\ &- 0{\cdot}56\,(41) - 0{\cdot}83\,(43) + 0{\cdot}83\,(44) + 1{\cdot}19\,(45) - 1{\cdot}19\,(45R) - 1{\cdot}68\,(46) \\ &+ 3{\cdot}84\,(47) - 2{\cdot}16\,(47M) - 1{\cdot}60\,(48) + 1{\cdot}60\,(50) \end{aligned}$$

Side 3 = Plantagenet–Buckingham

$$S_3 = b_2 \frac{\sin(37-36)\sin(44-45)\sin(22-24)\sin(29V-29)\sin(11-12)\sin(4-5)\sin(N-6)}{\sin(35-34)\sin(39-37)\sin(43-44)\sin(31-30)\sin(19-21)\sin(28-27)\sin(8-9)}$$

+Angle		C.D.	−Angle		C.D.
37 − 36		0·375	35 − 34		1·313
44 − 45	= 45° 32′ 03·91″	2·066	39 − 37	= 54° 02′ 01·75″	1·527
22 − 24	= 77° 38′ 25·30″	0·461	43 − 44	= 68° 28′ 34·93″	0·830
29V − 29		1·093	31 − 30		1·641
11 − 12		0·627	19 − 21		0·611
4 − 5		0·648	28 − 27		2·190
N − 6		3·334	8 − 9		0·856

$$\therefore d\log S_3 = \begin{aligned} &0{\cdot}65\,(4) - 0{\cdot}65\,(5) - 3{\cdot}33\,(6) - 0{\cdot}86\,(8) + 0{\cdot}86\,(9) + 0{\cdot}63\,(11) \\ &- 0{\cdot}63\,(12) - 0{\cdot}61\,(19) + 0{\cdot}61\,(21) + 0{\cdot}46\,(22) - 0{\cdot}46\,(24) + 2{\cdot}19\,(27) \\ &- 2{\cdot}19\,(28) - 1{\cdot}09\,(29) + 1{\cdot}09\,(29V) + 1{\cdot}64\,(30) - 1{\cdot}64\,(31) + 1{\cdot}31\,(34) \\ &- 1{\cdot}31\,(35) - 0{\cdot}38\,(36) + 1{\cdot}90\,(37) - 1{\cdot}53\,(39) - 0{\cdot}83\,(43) + 2{\cdot}90\,(44) \\ &- 2{\cdot}07\,(45) \end{aligned}$$

FORMATION OF EQUATIONS FOR WEIGHTS OF EXTERIOR SIDES—*Concluded*

SIDE 2 = VANKLEEK — PLANTAGENET

$$S_2 = b_2 \frac{\sin (21 - 22) \sin (11 - 12) \sin (4 - 5) \sin (N - 6)}{\sin (31 - 30) \sin (19 - 21) \sin (28 - 27) \sin (8 - 9)}$$

+ Angle	C.D.	− Angle	C.D.
21 − 22	+0·966	31 − 30	1·641
11 − 12	+0·627	19 − 21	0·611
4 − 5	+0·648	28 − 27	2·190
N − 6	+3·334	8 − 9	0·856

$\therefore d \log S_2 = 0{\cdot}65\,(4) - 0{\cdot}65\,(5) - 3{\cdot}33\,(6) - 0{\cdot}86\,(8) + 0{\cdot}86\,(9) + 0{\cdot}63\,(11) - 0{\cdot}63\,(12) - 0{\cdot}61\,(19) + 1{\cdot}58\,(21) - 0{\cdot}97\,(22) + 2{\cdot}19\,(27) - 2{\cdot}19\,(28) + 1{\cdot}64\,(30) - 1{\cdot}64\,(31)$

SIDE 1 = RIGAUD — VANKLEEK

(b_1 = Newton—Rigaud)
(b_2 = Newtom—Huntingdon)

$$S_1 = b_2 \frac{\sin (R - 4) \sin (9 - 11) \sin (N - 6)}{\sin (1 - N) \sin (28 - 27) \sin (8 - 9)}$$

+ Angle	C.D.	− Angle	C.D.
R − 4	−0·256	1 − N = 56° 26′ 12·″136	1·397
9 − 11 = 63° 14′ 08·″19	1·062	28 − 27 = 43° 52′ 57·″99	2·190
N − 6 = 32° 16′ 46·556″	3·334	8 − 9 = 67° 52′ 16·″90	0·856

$\therefore d \log S_1 = -1{\cdot}40\,(1) + 0{\cdot}26\,(4) - 3{\cdot}33\,(6) - 0{\cdot}86\,(8) + 1{\cdot}92\,(9) - 1{\cdot}06\,(11) + 2{\cdot}19\,(27) - 2{\cdot}19\,(28)$

Correlate

The correlate equations are formed now by writing the coefficients of each Equation I is written in column of K_1, equation II in column K_2, etc.,

CORRELATE EQUATIONS

	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}
(1)=	− 1·74			+ 2·91			−1·74			+1·40				+ 1		+ 1	
(2)=				−11·03										− 1	+ 1		
(3)=	+21·73			+ 8·12			+3·08								− 1	− 1	
(4)=	+ 0·39																
(5)=	− 0·65																
(6)=		+16·64					+5·43			+3·33	−1		+1				
(7)=		−21·72									+1	+1					
(7H)=		+ 5·08					−3·69					−1	−1				
(8)=		− 0·41								+0·86	+1		−1				
(9)=	−28·94									−1·92							
(10)=	+30·20			+ 1·26											+1	+1	
(11)=	− 1·26			− 1·89				+0·63		+1·06				−1	−1		
(12)=		+ 1·50		+ 0·63				−2·13				−1	+1	+1		−1	
(13)=		− 1·09						+1·50			−1	+1					
(14)=		+ 1·81					−1·81					+1	+1				
(15)=		− 4·32					+4·32	+2·51			+1	−1					
(16)=		+ 2·51					−2·51	−3·82			−1		−1				
(17)=								+1·31									
(18)=		− 7·60									−1	−1					
(19)=		+ 6·76		+ 3·25			+0·78					+1	−1	−1		+1	
(20)=				− 5·68										+1	−1		
(21)=				+ 2·44			−0·61								+1	−1	
(22)=						+3·45											
(23)=						−5·46											+1
(24)=						+2·02											−1
(25)=		+ 0·84					−0·17				+1		+1				
(26)=	− 4·20			+ 0·75			−0·75			+4·20				−1		−1	
(27)=	+ 6·39									−6·39							
(28)=	− 2·19			− 4·01			+4·01	+3·27		+2·19				+1	+1		
(29)=				+ 3·27			−3·27	−4·36							−1	+1	
(29V)=								+1·09									
(30)=								+1·64									
(31)=						+3·13		−4·77									
(32)=						−3·49		+3·13	−0·35								+1
(33)=						+0·35			+2·69								−1
(33P)=									−2·33								
(34)=			− 3·04						−1·31								
(35)=			+ 1·31						+2·03								
(35B)=			+ 1·72						−0·71								
(36)=			+ 0·38														
(37)=			− 4·88			+3·09											+1
(38)=						−8·95											−1
(39)=					+ 4·65	+5·86											
(40)=					− 0·85												
(41)=			+ 4·50		− 3·81												
(42)=								+1·02									
(43)=						+0·83		−1·85									+1
(44)=						−2·90		+0·83	−2·07								−1
(45)=						+2·07			+3·26								
(45R)=									−1·19								
(46)=					+ 1·89				−1·68								
(47)=					− 1·68				+3·84								
(47M)=					− 0·21				−2·16								
(48)=					+ 2·68				−1·60								
(49)=					−10·73												
(50)=			−11·19		+ 8·05				+4·76								
(51)=			+16·14														
(52)=			− 4·95						−3·16								

Note.—For direction 18 the weight is $\frac{11}{16} = 0{\cdot}6875$

The term $\frac{1}{p} = 1{\cdot}454545$ was set in margin of correlative equations and this multiplier used in terms where coefficients of v_{18} occurred.

Equations

"*v*" of the condition equations in vertical column of each K. giving value of each "*v*" in terms of *K*'s.

RIGAUD—NORTH MOUNTAIN FIGURE

K_{18}	K_{19}	K_{20}	K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	K_{28}		Side 1	Side 2	Side 3	Side 4	Side 5	Side 6	Side 7	Side 8	Check
....	....	....	+1	....	....	....	....	....	....	....	(1)	−1·40	.....	.....	.....	.....	.....	.....	.....	+ 2·43
....	....	....	....	....	....	....	....	....	....	....	(2)	.....	.....	.....	.....	.....	.....	.....	.....	−11·03
....	....	+1	....	....	....	....	....	....	....	....	(3)	.....	.....	.....	.....	.....	.....	.....	.....	+31·93
....	....	−1	....	....	....	....	....	....	....	....	(4)	+0·26	+0·65	+0·65	+·065	+0·65	+0·65	.....	.....	+ 2·90
....	....	....	−1	....	....	....	....	....	....	+1	(5)	.....	−0·65	−0·65	−0·65	−0·65	−0·65	+0·38	+0·38	− 3·14
....	....	....	....	....	....	....	....	....	....	−1	(6)	−3·33	−3·33	−3·33	−3·33	−3·33	−3·33	+3·69	.....	+ 8·11
....	....	....	....	....	....	....	....	....	....	....	(7)	.....	.....	.....	.....	.....	.....	.....	.....	−19·72
....	....	....	....	....	....	....	....	....	....	....	(7H)	.....	.....	.....	.....	.....	.....	−3·69	.....	− 4·30
....	....	....	....	....	....	....	....	....	....	+1	(8)	−0·86	−0·86	−0·86	−0·86	−0·86	−0·86	−0·86	−0·45	− 5·02
....	....	....	+1	....	....	....	....	....	....	−1	(9)	+1·92	+0·86	+0·86	+0·86	+0·86	+0·86	+0·86	+0·86	−22·92
....	....	−1	....	....	....	....	....	....	....	....	(10)	.....	.....	.....	.....	.....	.....	.....	.....	+32·46
....	....	+1	−1	....	....	....	....	....	....	....	(11)	−1·06	+0·63	+0·63	+0·63	+0·63	+0·63	.....	.....	− 1·37
....	....	....	....	....	....	....	....	....	....	....	(12)	.....	−0·63	−0·63	−0·63	−0·63	−0·63	+1·50	.....	− 1·65
....	....	....	....	....	....	....	....	....	....	....	(13)	.....	.....	.....	.....	.....	.....	−1·50	−0·41	− 1·50
....	....	....	....	....	....	....	....	....	....	....	(14)	.....	.....	.....	.....	.....	.....	−1·81	−1·81	− 1·62
....	....	....	....	....	....	....	....	....	....	....	(15)	.....	.....	.....	.....	.....	.....	+1·81	+1·81	+ 6·13
....	....	....	....	+1	....	....	....	....	....	....	(16)	.....	.....	.....	.....	.....	.....	.....	.....	− 4·82
....	....	....	....	−1	....	....	....	....	....	....	(17)	.....	.....	.....	.....	.....	.....	.....	.....	+ 0·31
....	....	....	....	....	....	....	....	....	....	....	(18)	.....	.....	.....	.....	.....	.....	.....	.....	− 9·60
....	....	....	....	....	....	....	....	....	....	....	(19)	.....	−0·61	−0·61	−0·61	−0·61	−0·61	+0·17	.....	+ 7·91
....	....	....	....	....	....	....	....	....	....	....	(20)	.....	.....	.....	.....	.....	.....	.....	.....	− 5·68
....	....	....	....	....	+1	....	....	....	....	....	(21)	.....	+1·58	+0·61	+0·61	+0·61	+0·61	.....	.....	+ 6·85
+1	+1	....	....	....	−1	....	....	....	....	....	(22)	.....	−0·97	+0·46	+0·46	+0·46	+0·46	.....	.....	+ 5·32
−1	....	....	....	....	....	....	....	....	....	....	(23)	.....	.....	.....	.....	.....	.....	.....	.....	− 5·46
....	−1	....	....	+1	....	....	....	....	....	....	(24)	.....	.....	−0·46	−0·46	−0·46	−0·46	+1·33	.....	+ 0·51
....	....	....	....	−1	....	....	....	....	....	....	(25)	.....	.....	.....	.....	.....	.....	−1·50	.....	+ 0·17
....	....	....	−1	....	....	....	....	....	....	....	(26)	.....	.....	.....	.....	.....	.....	.....	.....	− 3·00
....	....	+1	....	....	....	....	....	....	....	....	(27)	+2·19	+2·19	+2·19	+2·19	+2·19	+2·19	.....	.....	+14·14
....	....	−1	+1	....	....	....	....	....	....	....	(28)	−2·19	−2·19	−2·19	−2·19	−2·19	−2·19	.....	.....	− 7·87
....	....	....	....	....	−1	....	....	....	....	....	(29)	.....	.....	−1·09	−1·09	−1·09	−1·09	.....	.....	− 9·72
....	....	....	....	....	+1	....	....	....	....	....	(29V)	.....	.....	+1·09	+1·09	+1·09	+1·09	.....	.....	+ 6·45
....	....	....	....	....	−1	....	....	....	....	....	(30)	.....	+1·64	+1·64	+1·64	+1·64	+1·64	.....	.....	+ 8·84
−1	−1	....	....	....	+1	....	....	....	....	....	(31)	.....	−1·64	−1·64	−1·64	−1·64	−1·64	.....	.....	−10·84
+1	....	....	....	....	....	....	....	....	....	....	(32)	.....	.....	.....	−0·35	−0·35	−0·35	.....	.....	+ 0·24
....	+1	....	....	....	....	−1	....	....	....	....	(33)	.....	.....	.....	+0·35	+0·35	+0·35	.....	.....	+ 3·09
....	....	....	....	....	....	+1	....	....	....	....	(33P)	.....	.....	.....	.....	.....	.....	.....	.....	− 1·33
....	....	....	....	....	....	−1	....	....	....	....	(34)	.....	.....	+1·31	.....	.....	.....	.....	.....	− 4·04
....	....	....	....	....	....	+1	−1	....	....	....	(35)	.....	.....	−1·31	+0·71	.....	.....	.....	.....	+ 2·74
....	....	....	....	....	....	....	+1	....	....	....	(35B)	.....	.....	.....	−0·71	.....	.....	.....	.....	+ 1·30
....	....	....	....	....	....	−1	+1	....	....	....	(36)	.....	.....	−0·38	+0·56	.....	.....	.....	.....	+ 0·56
....	−1	....	....	....	....	+1	....	....	....	....	(37)	.....	.....	+1·90	+1·53	+1·53	+1·53	.....	.....	+ 5·70
+1	....	....	....	....	....	....	....	....	....	....	(38)	.....	.....	.....	.....	.....	.....	.....	.....	− 8·95
−1	+1	....	....	....	....	....	....	....	−1	....	(39)	.....	.....	−1·53	−1·53	−1·53	−2·37	.....	.....	+ 2·55
....	....	....	....	....	....	....	....	−1	+1	....	(40)	.....	.....	.....	.....	−0·26	+0·85	.....	.....	− 0·26
....	....	....	....	....	....	....	−1	+1	....	....	(41)	.....	.....	.....	−0·56	+0·26	.....	.....	.....	+ 0·39
....	....	....	....	+1	....	....	....	....	....	....	(42)	.....	.....	.....	.....	.....	.....	−1·02	.....	+ 1·00
....	+1	....	....	−1	....	....	....	....	....	....	(43)	.....	.....	−0·83	−0·83	−0·83	−0·83	+1·02	.....	− 2·32
−1	....	....	....	....	....	....	....	....	....	....	(44)	.....	.....	+2·90	+0·83	+0·83	+0·83	.....	.....	− 0·75
+1	−1	....	....	....	....	....	....	....	+1	....	(45)	.....	.....	−2·07	+1·19	+1·19	.....	.....	.....	+ 6·64
....	....	....	....	....	....	....	....	....	−1	....	(45R)	.....	.....	.....	−1·19	−1·19	.....	.....	.....	− 4·57
....	....	....	....	....	....	....	....	....	+1	....	(46)	.....	.....	.....	−1·68	−1·68	−1·68	.....	.....	− 3·83
....	....	....	....	....	....	....	....	+1	−1	....	(47)	.....	.....	.....	+3·84	+1·68	+1·68	.....	.....	+ 9·36
....	....	....	....	....	....	....	....	−1	....	....	(47M)	.....	.....	.....	−2·16	.....	.....	.....	.....	− 5·53
....	....	....	....	....	....	....	....	+1	....	....	(48)	.....	.....	.....	−1·60	−1·60	.....	.....	.....	− 1·12
....	....	....	....	....	....	....	....	....	....	....	(49)	.....	.....	.....	.....	.....	.....	.....	.....	−10·73
....	....	....	....	....	....	....	+1	−1	....	....	(50)	.....	.....	.....	+1·60	+1·60	.....	.....	.....	+ 4·82
....	....	....	....	....	....	....	....	....	....	....	(51)	.....	.....	.....	.....	.....	.....	.....	.....	+16·14
....	....	....	....	....	....	....	−1	....	....	....	(52)	.....	.....	.....	.....	.....	.....	.....	.....	− 9·11

Substitution of the values of the *v*'s from the correlate equations in the

K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}
2290·2145	.....	.....	+217·4495	.....	.....	+ 64·3241	− 7·9551	.....	− 11·4750	.....
	+ 936·71693	.....	+ 22·9150	.....	.....	+ 48·5014	− 25·2614	.....	+ 55·0586	−32·61546
		+468·3431	.....	−107·2245	− 15·0792	.....	.....	− 32·2019	.....	.....
			+277·7340	.....	.....	− 6·3427	− 29·9025	.....	− 3·5613	.....
				+230·4175	+ 27·2490	.....	.....	+ 24·8572	.....	.....
					+205·2680	.....	− 29·7963	+ 14·9142	.....	.....
						+112·1985	+ 47·8013	.....	+ 21·2778	+ 1·23
							+101·0742	− 2·8136	+ 7·8291	+ 4·83
								+ 92·8940	.....	.....
									+ 81·8667	− 2·47
										+8·454545

K_{24}	K_{25}	K_{26}	K_{27}	K_{28}	Abs. Term	Side 1	Side 2
.....	.....	.....	.....	+ 28·29	− 66·60	−32·9016	− 6·2160
.....	.....	.....	.....	− 17·05	− 8·50	−55·0586	−60·1272
− 0·91	− 9·95	+ 15·69	.....	.....	− 18·60	.....	.....
.....	.....	.....	.....	.....	− 0·80	+ 6·7113	+ 9·0670
.....	+ 11·86	− 9·80	− 1·93	.....	+ 5·20	.....	.....
+ 2·74	.....	.....	− 3·79	.....	+ 13·80	.....	− 8·4797
.....	.....	.....	.....	− 5·43	+ 10·50	−24·4278	−28·3034
.....	.....	.....	.....	.....	− 1·20	− 7·8291	+ 5·0899
− 1·68	+ 5·18	− 0·36	− 1·07	.....	− 2·80	.....	.....
.....	.....	.....	.....	− 0·55	+ 10·00	−37·3887	−31·6021
.....	.....	.....	.....	+ 2·00	+ 1·132	+ 2·47	+ 2·47
.....	.....	.....	.....	.....	+ 3·295	.....	+ 0·02
.....	.....	.....	.....	− 2·00	+ 0·255	− 2·47	− 2·49
.....	.....	.....	.....	.....	+ 1·459	− 2·53	− 2·84
.....	.....	.....	.....	.....	+ 0·317	− 1·13	− 1·24
.....	.....	.....	.....	.....	− 1·288	− 1·40	− 1·56
+ 2·00	.....	.....	.....	.....	− 0·080	.....	.....
.....	.....	.....	+ 2·00	.....	− 0·203	.....	+ 0·67
− 2·00	.....	.....	− 2·00	.....	+ 1·357	.....	+ 0·67
.....	.....	.....	.....	.....	+ 0·202	+ 3·06	+ 4·36
.....	.....	.....	.....	− 2·00	+ 0·705	− 0·61	− 1·31
.....	.....	.....	.....	.....	+ 0·059	.....	.....
.....	.....	.....	.....	.....	+ 0·688	.....	− 0·73
+ 6·00	− 2·00	.....	.....	.....	− 1·644	.....	.....
	+ 6·00	− 2·00	.....	.....	+ 0·024	.....	.....
		+ 6·00	− 2·00	.....	+ 0·553	.....	.....
			+ 6·00	.....	− 0·153	.....	.....
				+ 4·00	+ 0·731	+ 0·55	+ 0·96
						+28·2583	+32·9877

Condition Equations gives us the following normal equations.—

K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}	K_{23}
.....	.....	+ 1·53	+ 7·54	+ 10·93	.....	.....	.....	− 1·54	−26·76	.....	.....
−5·44546	+ 6·85	− 5·26	.....	+ 5·26	.....	.....	.....	.....	.....	+ 1·67	.....
.....	.....	.....	.....	.....	− 4·88	.....	+ 4·88	.....	.....	.....	.....
+2·62	− 2·62	+ 2·77	− 15·16	− 1·25	.....	.....	.....	+ 8·98	+ 0·04	.....	− 0·83
.....	.....	.....	.....	.....	.....	− 4·65	+ 4·65	.....	.....	.....	.....
.....	.....	.....	.....	.....	+ 4·45	− 7·55	+ 0·18	.....	.....	+ 1·19	− 0·32
−1·66	+ 8·87	+ 2·24	+ 3·59	− 5·95	.....	.....	.....	− 0·93	+ 3·02	− 2·34	+ 2·66
+1·12	+ 1·69	+ 0·51	+ 7·00	− 2·23	+ 0·45	+ 7·07	+ 2·92	− 2·64	+ 2·64	− 2·26	− 0·96
.....	.....	.....	.....	.....	− 0·97	+ 4·98	− 0·57	.....	.....	.....	.....
.....	+ 2·47	− 1·67	+ 1·13	− 2·80	.....	.....	.....	− 7·52	− 3·59	.....	.....
+0·454545	.....	.....	.....	.....	.....	.....	.....	.....	.....	− 2·00	.....
+8·454545	.....	− 2·00	.....	+ 2·00	.....	.....	.....	.....	.....	.....	.....
	+ 8·00	+ 2·00	.....	− 2·00	.....	.....	.....	.....	.....	− 2·00	.....
		+ 8·00	.....	.....	.....	.....	.....	− 2·00	+ 4·00	.....	.....
			+ 8·00	.....	.....	.....	.....	− 4·00	+ 2·00	.....	+ 2·00
				+ 8·00	.....	.....	.....	− 2·00	+ 2·00	.....	− 2·00
					+ 8·00	.....	.....	.....	.....	− 2·00	.....
						+ 8·00	.....	.....	.....	.....	− 2·00
							+ 8·00	.....	.....	− 2·00	− 2·00
								+ 6·00	− 2·00	.....	.....
									+ 6·00	.....	.....
										+ 6·00	.....
											+ 6·00

Side 3	Side 4	Side 5	Side 6	Side 7	Side 8	Formation Check	Check
− 6·2160	− 6·2160	− 6·2160	− 6·2160	−25·1354	−25·1354	+2458·2956	+2391·6956
−60·1272	−60·1272	−60·1272	−60·1272	+35·6879	−10·4639	+ 660·8690	+ 652·3690
−15·1149	−27·9687	−24·2004	− 7·4664	.....	.....	+ 243·9171	+ 225·3171
+ 3·1359	+ 3·1359	+3·1359	+ 3·1359	+ 1·4975	.....	+ 502·6614	+ 501·8614
− 7·1145	− 5·5617	− 5·2897	−17·7406	.....	.....	+ 139·7227	+ 144·9227
−20·9540	− 8·0021	− 8·0021	−15·3878	+ 3·5332	.....	+ 142·1632	+ 155·9632
−24·1474	−24·1474	−24·1474	−24·1474	+45·1357	+11·0953	+ 199·9706	+ 210·4706
+14·9729	+12·1593	+12·1593	+12·1593	− 3·8293	+ 3·9281	+ 129·9261	+ 128·7261
−17·1266	+38·9964	+24·0910	+ 8·6195	.....	.....	+ 157·7402	+ 154·9402
−31·6021	−31·6021	−31·6021	−31·6021	+ 9·8969	− 2·0382	− 51·5446	− 41·5446
+ 2·47	+ 2·47	+ 2·47	+ 2·47	− 2·74	+ 1·77	− 6·26636	− 5·13436
+ 0·02	+ 0·02	+ 0·02	+ 0·02	− 2·76	− 4·03	− 1·14636	+ 2·14864
− 2·49	− 2·49	− 2·49	− 2·49	− 6·26	− 1·36	+ 11·24	+ 11·495
− 2·84	− 2·84	− 2·84	− 2·84	+ 1·33	.....	− 5·28	− 3·821
− 1·12	− 1·12	− 1·12	− 1·12	.....	.....	+ 5·25	+ 5·567
− 1·68	− 1·68	− 1·68	− 1·68	− 1·33	.....	− 1·05	− 2·338
− 1·37	− 0·37	− 0·37	− 0·37	− 0·31	.....	+ 4·26	+ 4·180
− 1·34	+ 3·64	+ 3·64	+ 3·29	.....	.....	+ 17·75	+ 17·547
+ 0·37	− 2·17	− 2·17	− 1·82	− 0·31	.....	+ 6·63	+ 7·987
+ 4·36	+ 4·36	+ 4·36	+ 4·36	.....	.....	+ 17·21	+ 17·412
− 1·31	− 1·31	− 1·31	− 1·31	+ 0·48	+ 0·48	− 20·85	− 20·145
+ 0·37	+ 0·37	+ 0·37	+ 0·37	+ 0·79	.....	− 1·47	− 1·413
− 0·95	− 0·95	− 0·95	− 0·95	.....	.....	− 1·98	− 1·292
− 0·34	+ 1·33	+ 1·18	+ 1·18	.....	.....	+ 7·50	+ 5·856
+ 0·93	+ 1·30	+ 1·34	.....	.....	.....	+ 12·66	+ 12·684
.....	+ 2·24	− 1·00	+ 0·83	.....	.....	+ 9·60	+ 10·153
− 0·54	− 1·61	+ 0·29	− 0·14	.....	.....	− 4·79	− 4·943
+ 0·96	+ 0·96	+ 0·96	+ 0·96	− 5·03	− 0·93	+ 6·65	+ 7·381
+55·6332	+70·8477	+52·7587	+48·6698	+46·0366	+ 7·8068	.....	.....

Reduced Normal Equations

The table of reduced normal equations is a tabulation of the value of each unknown in terms of the subsequent unknowns and an absolute term.

Coefficients of K's

K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_9	K_{10}	K_8	K_{12}	K_{14}	K_{17}	K_{19}
	0	0	−·0949472	0	0	−·0280865	0	+·0050104	+·0034735	0	−·0006681	0	0
		0	−·0244631	0	0	−·0517781	0	−·0587783	+·0269680	+·0058134	+·0056154	0	0
			0	+·2289443	+·0321969	0	+·0687571	0	0	0	0	+·0104197	−·0104197
				0	0	+·0531585	0	+·0148861	+·1112132	−·0107326	−·0107334	0	0
					−·1155914	0	−·0849315	0	0	0	0	+·0054270	−·0280142
						0	−·0586854	0	+·1474832	0	0	−·0218877	+·0016311
							0	−·1730778	−·4462308	+·0114943	−·0244108	0	0
								0	+·0120339	0	0	+·0166120	+·0079656
									−·0076150	−·0076253	+·0234363	0	0
										−·0255387	+·0066361	−·0151795	−·0400723
											+·2406874	+·0033261	+·0087798
												−·0000721	−·0001905
													−·0043496

K_{11}	K_{16}	K_{18}	K_{15}	K_{13}	K_{26}	K_{24}	K_{27}	K_{25}	K_{22}	K_{23}	K_{28}	K_{20}	K_{21}
0	−·0047725	0	−·0032923	0	0	0	0	0	0	0	−·0123526	+·0006724	+·0116845
+·0348189	−·0056154	0	0	−·0073128	0	0	0	0	−·0017828	0	+·0182019	0	0
0	0	0	0	0	−·0335011	+·0019430	0	+·0212451	0	0	0	0	0
−·0031103	+·0094198	0	+·0618878	+·0108666	0	0	0	0	+·0001592	+·0032355	+·0088449	−·0355760	−·0100605
0	0	+·0225872	0	0	+·0301544	+·0010120	+·0093749	−·0465442	0	0	0	0	0
0	0	+·0347099	0	0	−·0060523	−·0135364	+·0176552	+·0070680	−·0058902	+·0015839	0	0	0
−·0276344	+·0621320	0	−·0236506	−·0780840	0	0	0	0	+·0226646	−·0244120	+·0509759	+·0037479	−·0364776
0	0	−·0653844	0	0	−·0132688	+·0213038	+·0078730	−·0425525	+·0007892	−·0002122	0	0	0
+·0139902	+·0257357	0	−·0065442	−·0076713	0	0	0	0 −	−·0042702	+·0061763	−·0199924	+·0972345	+·0579259
−·0381532	−·0093325	−·0854574	−·0577510	+·0304206	−·0027220	−·0053278	+·0074806	+·0023134	+·0134870	+·0316755	−·0253645	+·0195317	−·0157196
−·0274778	−·2374225	+·0187220	−·0108523	−·0260561	+·0005968	+·0011671	−·0016390	−·0005067	−·0005271	−·0120458	+·0234529	+·0013328	−·0026188
+·0293248	−·0878628	−·0004069	−·0223402	−·2606439	−·0000122	−·0000259	+·0000354	+·0000109	−·0097033	+·0077180	−·0058987	+·3089738	−·5177839
+·0052016	+·0004599	−·0168053	+·0079869	−·0043009	−·0153204	−·2424509	−·0082239	−·0057205	+·2578482	−·0053797	+·0036078	−·0027289	+·0022100
+·0139579	+·0012340	+·0106550	+·0214338	−·0115433	−·0017493	+·2633487	+·2525516	+·0170377	+·2545331	+·2490216	+·0096818	−·0073272	+·0059288
	−·0403503	+·0322507	+·0241440	−·0223303	+·0009111	+·0045877	+·0009420	−·0006477	+·2631947	+·0029191	−·2142800	+·0185120	+·0154431
		+·0015985	+·0120648	+·2520115	+·0000450	+·0002279	+·0000465	−·0000319	+·0114144	+·2695309	+·0576554	+·2757781	−·2812182
			+·0530314	−·0284547	+·0286951	−·0187605	−·2823000	+·0099657	−·0120034	+·2733331	+·0163860	−·0167570	+·0145056
				+·0448423	+·0030548	+·0066277	−·0135827	−·0005407	−·0010723	−·2792722	+·0290518	+·4896049	−·3076166
					−·0016084	−·0034816	+·0071382	+·0002841	+·2925212	+·0924759	+·2527673	−·0177372	+·0988982
						−·0018283	+·3745248	+·2703446	−·0064990	+·0067977	+·0008276	+·0007077	−·0003196
							+·1060661	+·3960089	+·0085576	+·0908613	+·0019146	+·0016303	−·0007451
								+·1615444	+·1204240	+·0184581	−·0040864	−·0034876	+·0015824
									+·0251161	+·0664811	+·0003713	+·0003149	−·0001434
										+·1667790	+·0428340	−·0069040	+·0311720
											+·0206790	−·1069930	+·0588290
												−·0626840	+·6296220
													−·1639080

The value of K_{28} is found in the last Elimination. This value, substituted in Reduced Normals gives the value of K_{27}. From these we get K_{26} and so on until values of all the unknowns are found as tabulated on this page.

K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_9	K_{10}	K_8	K_{12}	K_{14}	K_{17}	K_{13}
+ ·029078	+·009074	+·039714	−·022341	−·004574	−·064803	−·122394	−·055675	−·105985	+·070892	−·408651	−·278495	+·070345	−·227156
+ ·005354	+· 0	0	−·004610	0	0	−·016716	0	+·026544	−·007203	−·001200	−·037272	+·001013	+·002717
− ·000502	0	0	+·026555	0	0	−·002798	0	−·072580	−·014579	−·000995	−·230630	+·002037	+·035469
+ ·004750	−·006999	0	−·003401	0	0	−·019601	0	+·007687	−·009753	−·009018	+·002268	−·001387	−·003723
0	0	0	+·000039	0	+·000019	−·000292	−·000003	+·000074	+·000379	−·000144	+·000092	−·000064	+·002977
0	+·000068	0	−·000006	0	+·000225	−·000865	−·000030	+·000163	−·000514	+·000020	+·000370	−·009836	−·009709
0	0	+·001128	0	−·002471	+·000375	0	−·002259	0	+·000123	−·000027	+·000C01	−·000304	+·000904
0	0	0	0	−·000899	−·001693	0	−·000755	0	−·000717	+·000157	−·000003	+·000789	−·024221
0	0	+·000550	0	+·000286	−·003830	0	+·006028	0	−·001507	+·000330	−·000007	−·068598	+·074511
0	0	+·008733	0	−·507860	+·001578	0	+·003459	0	+·000710	−·000156	+·000003	+·003993	+·000456
0	−·001651	0	+·002453	0	0	−·017627	0	−·001732	+·006867	−·005882	−·058838	−·000971	−·002606
+ 002089	0	0	−·039273	0	0	+·015008	0	+·004153	+·036647	+·006887	+·014177	−·005068	−·013601
0	0,	0	0	−·004022	−·006180	0	+·011641	0	+·015215	−·003333	+0·000072	+·002992	−·001897
+ ·000890	+·001047	0	−·001756	0	0	−·011585	0	−·004798	+·001740	+·044268	+·016382	−·000086	−·000230
0	−·002001	0	+·000179	0	0	+·001588	0	−·000804	+·002192	+·001579	−·001685	−·000299	−·000802
0	0	+·002052	0	+·005516	−·000321	0	−·001569	0	+·007891	−·001729	+·000038	+·000856	−·196911
0	0	−·000048	0	−·000025	+·000100	0	−·000076	0	+·000070	−·000015	0	−·004588	K_{13}
+ 0·000517	−·004344	0	+·008303	0	0	+·118882	0	−·018129	−·005133	−·186178	−·773527	K_{17}	
0	−·003279	0	+·006054	0	0	−·006484	0	+·004301	+·014406	−·564087	K_{14}		
+ ·000477	+·003701	0	+·015262	0	+·020239	−·061237	+·001651	−·001045	+·137232	K_{12}			
− ·000812	+·009531	0	−·002414	0	0	+·028065	0	−·162151	K_8				
0	0	+·005072	0	−·006265	−·004329	0	+·073762	K_{10}					
+ ·005507	+·010151	0	−·010422	0	0	−·196056	K_9						
0	0	−·001887	0	+·006776	−·058620	K_7							
0	0	−·003099	0	−·013538	K_6								
+ ·002410	+·000621	0	−·025578	K_5									
0	0	+·052215	K_4										
0	+·015919	K_3											
+ ·049758	K_2												
K_1													

K_{11}	K_{16}	K_{18}	K_{15}	K_{13}	K_{26}	K_{24}	K_{27}	K_{25}	K_{22}	K_{23}	K_{28}	K_{29}	K_{21}
− ·105418	+ ·118654	− ·169363	− ·126160	+ ·275659	− ·237916	+ ·273619	− ·105006	+ ·053691	− ·043106	− ·086916	− ·719818	− ·671328	+ ·458246
+ − ·007077	− ·128867	+ ·006647	− ·140964	+ + ·045320	− ·000146	− ·000341	+ ·000725	− ·000066	+ ·014284	+ ·026958	+ ·288522	− ·075110	+ ·458246
− + ·013863	− ·205851	+ ·012508	− ·365460	+ + ·013240	− ·000528	− ·001217	+ + ·002603	− ·000235	+ ·005153	+ ·079864	+ ·046790	− ·746438	K_{21}
− − ·082392	− ·022169	− ·006301	− ·011171	− ·097191	− ·000318	− ·000736	+ ·001571	− ·000143	− ·016470	− ·007951	− ·384506	K_{29}	
+ + ·000035	+ ·003222	+ ·003268	− ·003339	+ ·001106	+ ·000081	+ ·001086	+ ·000221	+ ·000795	+ ·001994	+ ·011955	K_{28}		
− − ·010040	− ·000435	+ ·000458	+ ·000041	− ·001158	+ ·000248	− ·000326	− ·004594	− ·000958	− ·038145	K_{23}			
− − ·000034	− ·000002	+ ·000529	− ·000029	+ ·000015	+ ·014351	+ ·021022	+ ·008575	+ ·053084	K_{22}				
− − ·000090	− ·000004	+ ·027074	+ ·001303	− ·000685	− ·035919	− ·010172	− ·095905	K_{25}					
− − ·001298	+ ·000064	− ·005308	+ ·001875	− ·000985	− ·000517	+ ·282935	K_{27}						
− − ·000237	− ·000012	− ·007480	− ·000796	+ ·000419	− ·260664	K_{24}							
− − ·005041	+ ·056889	− ·006423	+ ·010123	+ ·225740	K_{26}								
− − ·015321	− ·007656	− ·033653	− ·634577	K_{13}									
− − ·005742	− ·000285	− ·178044	K_{15}										
+ − ·007523	− ·186457	K_{18}											
− ·057461	K_{16}												
K_{11}													

EVALUATION OF *V*'S.

The substitution of these values of the *K*'s in the correlate equations is done in the following table, giving the values of the corrections to the observed directions.

	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}
(1)	− ·08658			−·07385			+ ·34114			− ·22701				−·77353
(2)				+·27992										+·77353
(3)	+1·08124			−·20607			− ·60385							
(4)	+ ·01941													
(5)	− ·03234													
(6)		+·26489					−1·06458			− ·53996	+·05746		+·22574	
(7)		−·34576									−·05746	−·56409		
(7H)		+·08087					+ ·72345					+·56409	−·22574	
(8)		−·00653								− ·13945	−·05746		−·22574	
(9)	−1·44000									+ ·31133				
(10)	+1·50269			−·03198										
(11)	− ·06270			+·04796				+·08646		− ·17188				+·77353
(12)		+·02388		−0·01599				−·29230				+·56409	+·22574	−·77353
(13)		−·01735						+·20585			+·05746	−·56409		
(14)		+·02881					+ ·35486					−·56409	+·22574	
(15)		−·06877					− ·84696	+·34445			−·05746	+·56409		
(16)		+·03996					+ ·49210	−·52423			+·05746		−·22574	
(17)								+·17977						
(18)		−·12098									+·05746	+·56409		
(19)		+·10761		−·08248			− ·15292					−·56409	−·22574	+·77353
(20)				+·14415										−·77353
(21)				−·06192			+ ·11959							
(22)						−·20224								
(23)						+·32007								
(24)						−·11841								
(25)		+·01337					+ ·03333				−·05746		+·22574	
(26)	− ·20898			−·01903			+ ·14704			− ·68103				+·77353
(27)	+ ·31795									+1·03614				
(28)	− ·10897			+·10177			− ·78618	+·44875		− ·35511				−·77353
(29)				−·08299			+ ·64110	−·59833						
(29V)								+·14958						
(30)								+·22506						
(31)						−·18348		−·65460						
(32)						+·20458		+·42954	−·02582					
(33)						−·02052			+·19842					
(33P)									−·17187					
(34)			−·15873						−·09663					
(35)			+·06840						+·14974					
(35B)			+·08981						−·05237					
(36)			+·01984											
(37)			−·25481			−·18114								
(38)						+·52465								
(39)					−·06295	−·34351								
(40)					+·01151									
(41)			+·23497		+·05158									
(42)								+·13998						
(43)						−·04865		−·25388						

(44)	.....	.....	.....	.....	.....	+·17000	.....	+·11390	−·15269	.....	.....	.....	.....	.....
(45)	.....	.....	.....	.....	.....	−·12134	.....	.....	+·24046	.....	.....	.....	.....	.....
(45R)	.....	.....	.....	.....	.....	.....	.....	.....	−·08778	.....	.....	.....	.....	.....
(46)	.....	.....	.....	.....	−·02559	.....	.....	.....	−·12392	.....	.....	.....	.....	.....
(47)	.....	.....	.....	.....	+·02274	.....	.....	.....	+·28325	.....	.....	.....	.....	.....
(47M)	.....	.....	.....	.....	+·00284	.....	.....	.....	−·15933	.....	.....	.....	.....	.....
(48)	.....	.....	.....	.....	−·03628	.....	.....	.....	−·11802	.....	.....	.....	.....	.....
(49)	.....	.....	.....	.....	+·14526	.....	.....	.....	.....	.....	.....	.....	.....	.....
(50)	.....	.....	−·58429	.....	−·10898	.....	.....	.....	+·35111	.....	.....	.....	.....	.....
(51)	.....	.....	+·84275	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
(52)	.....	.....	−·25846	.....	.....	.....	.....	.....	−·23309	.....	.....	.....	.....	.....

NOTE.—V_{18} is obtained by multiplying sum of line 18. (·50057) by $\frac{1}{p}$ (1·454545) giving ·72810 as value of v_{18}.

EVALUATION OF *V*'S—*Continued.*

The substitution of these values of the *K*'s in the correlate equations is done in the following table, giving the values of the corrections to the observed directions.

	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	K_{28}	v's
(1)		−·18645					+·45825								−·54803
(2)	−·63458														+·41887
(3)	+·63458	+·18645				−·74644									+·34591
(4)						+·74644									+·76585
(5)							−·45825							−·38451	−·87510
(6)														+·38451	−·67194
(7)															−·96731
(7H)															+1·14267
(8)														−·38451	−·81369
(9)							+·45825							+·38451	−·28591
(10)	−·63458	−·18645				+·74644									+1·39612
(11)	+·63458					−·74644	−·45825								+·10326
(12)		+·18645													−·08166
(13)															−·31813
(14)															+·04532
(15)															−·06465
(16)								−·03814							−·19859
(17)								+·03814							+·21791
(18)															+·72810
(19)		−·18645													−·33054
(20)	+·63458														+·00520
(21)	−·63458	+·18645							+·01195						−·37851
(22)				−·17804	−·19691				−·01195						−·58914
(23)			−·00459	+·17804											+·49352
(24)			+·00459		+·19691			−·03814							+·04495
(25)								+·03814							+·25312
(26)		+·18645					−·45825								−·26027
(27)						−·74644									+·60765
(28)	−·63458					+·74644	+·45825								−·90316
(29)	+·63458	−·18645							−·01195						+·39596
(29V)									+·01195						+·16153
(30)									−·01195						+·21311
(31)				+·17804	+·19691				+·01195						−·45118
(32)			−·00459	−·17804											+·42567
(33)			+·00459		−·19691					−·28293					−·29735
(33P)										+·28293					+·11106
(34)										−·28293					−·53829
(35)										+·28293	−·05308				+·44799
(35B)											+·05308				+·09052
(36)										−·28293	+·05308				−·21001
(37)			−·00459		+·19691					+·28293					+·03930
(38)			+·00459	−·17804											+·35120
(39)				+·17804	−·19691								+·09590		−·32943
(40)												+·26066	−·09590		+·17627
(41)											−·05308	−·26066			−·02719
(42)								−·03814							+·10184
(43)			−·00459		−·19691			+·03814							−·46589

(44)	.....	.....	+·00459	+·17804	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+·31384
(45)	.....	.....	.....	−·17804	+·19691	.....	.....	.....	.....	.....	.....	.....	−·09590	.....	+·04209
(45R)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+·09590	.....	+·00812
(46)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	−·09590	.....	−·24541
(47)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	−·26066	+·09590	.....	+·14123
(47M)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+·26066	.....	.....	+·10417
(48)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	−·26066	.....	.....	−·41496
(49)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+·14526
(50)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+·05308	+·26066	.....	.....	−·02842
(51)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	+·84275
(52)	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	−·05308	.....	.....	.....	−·54463

NOTE.—V_{18} is obtained by multiplying sum of line 18. (·50057) by $\frac{1}{p}$ (1·454545) giving ·72810 as value of v_{18}.

O−C Test

A good check of the adjustment is the O−C test in which the computed corrections to the directions are substituted in the condition equations and the absolute term thus computed is compared with the absolute term of the condition equation, (the observed absolute term).

The following table gives the observed and computed absolute terms and the difference " O−C ".

Number	Absolute Term		
	Observed "O"	Computed "C"	O–C
1	−66·60	−66·59857	−·00143
2	− 8·50	− 8·49900	−·00100
3	−18·60	−18·60095	+·00095
4	− 0·80	− 0·80028	+·00028
5	+ 5·20	+ 5·20057	−·00057
6	+13·80	+13·80016	−·00016
7	+10·50	+10·50019	−·00019
8	+ 1·20	+ 1·20019	−·00019
9	− 2·80	− 2·79988	−·00012
10	−10·00	−10·00009	+·00009
11	+ 1·132	+ 1·13197	−·00003
12	+ 3·295	+ 3·29512	−·00012
13	+ 0·255	+ 0·25501	−·00001
14	+ 1·459	+ 1·45897	−·00003
15	+ 0·317	+ 0·31701	−·00001
16	− 1·288	− 1·28804	+·00004
17	− 0·080	− 0·07996	−·00004
18	− 0·203	− 0·20307	+·00007
19	+ 1·357	+ 1·35697	+·00003
20	+ 0·202	+ 0·20199	+·00001
21	+ 0·705	+ 0·70499	+·00001
22	+ 0·057	+ 0·05694	+·00006
23	+ 0·688	+ 0·68809	−·00009
24	+ 1·644	+ 1·64400	·00000
25	− 0·153	− 0·15303	+·00003
26	+ 0·553	+ 0·55294	+·00006
27	+ 0·024	+ 0·02408	−·00008
28	+ 0·731	+ 0·73094	+·00006

The following is a table of observed and adjusted directions:—

ADJUSTED DIRECTIONS

Number	Observed Value			"v"	Adjusted Value		
	°	′	″		°	′	″
1	0	00	00·00	−0·548	359	59	59·452
2	324	06	44·12	+0·419	324	06	44·539
3	309	34	33·07	+0·346	309	34	33·416
4	263	03	18·98	+0·766	263	03	19·746
5	190	10	23·75	−0·875	190	10	22·875
6	327	15	25·56	−0·672	327	15	24·888
7	320	02	51·07	−0·967	320	02	50·103
7H	297	31	46·80	+1·143	297	31	47·943
8	131	06	25·09	−0·814	131	06	24·276
9	63	14	08·19	−0·286	63	14	07·904
10	59	04	29·01	+1·396	59	04	30·406
11	0	00	00·00	+0·103	00	00	00·103
12	286	35	21·55	−0·082	286	35	21·468
13	232	04	16·07	−0·318	232	04	15·752
14	49	18	33·51	+0·045	49	18	33·555
15	0	00	00·00	−0·065	359	59	59·935
16	319	58	56·25	−0·199	319	58	56·051
17	261	56	16·77	+0·218	261	56	16·998
18	156	27	26·85	+0·728	156	27	27·578
19	139	08	59·33	−0·331	139	08	58·999
20	106	10	18·15	+0·005	106	10	18·155
21	65	20	58·46	−0·379	65	20	58·081
22	00	00	00·00	−0·589	359	59	59·411
23	328	34	49·10	+0·494	328	34	49·594
24	282	21	34·70	+0·045	282	21	34·745
25	224	36	49·86	+0·253	224	36	50·113
26	0	00	00·00	−0·260	359	59	59·740
27	26	37	08·18	+0·608	26	37	08·788
28	70	30	06·17	−0·903	70	30	05·267
29	103	17	26·28	+0·396	103	17	26·676
29V	165	51	43·06	+0·162	165	51	43·222
30	0	00	00·00	+0·213	0	00	00·213
31	52	04	47·26	−0·451	52	04	46·809
32	85	57	48·88	+0·426	85	57	49·306
33	166	23	46·19	−0·297	166	23	45·893
33B	208	26	59·67	+0·111	208	26	59·781
34	0	00	00·00	−0·538	359	59	59·462
35	58	03	23·15	+0·448	58	03	23·598
35B	129	19	57·74	+0·091	129	19	57·831
36	115	39	30·31	−0·210	115	39	30·100
37	195	32	53·53	+0·039	195	32	53·569
38	229	48	46·21	+0·351	229	48	46·561
39	249	34	55·28	−0·329	249	34	54·951
40	317	41	46·27	+0·176	317	41	46·446
41	40	37	42·90	−0·027	40	37	42·873
42	132	41	11·39	+0·102	132	41	11·492
43	68	28	34·93	−0·466	68	28	34·464
44	0	00	00·00	+0·314	0	00	00·314
45	314	27	56·09	+0·042	314	27	56·132
45R	253	58	34·71	+0·008	253	58	34·718
46	12	58	50·18	−0·245	12	58	49·935
47	321	34	58·91	+0·141	321	34	59·051
47M	277	20	01·12	+0·104	277	20	01·224
48	52	49	10·09	−0·415	52	49	09·675
49	14	39	42·99	+0·145	14	39	43·135
50	0	00	00·00	−0·028	359	59	59·972
51	349	20	44·23	+0·843	349	20	45·073
52	326	18	20·00	−0·545	326	18	19·455

Table of Triangles

In the following table are given the adjusted and observed angles of each triangle, the corrections to each angle, the spherical excess and the triangle closures.

TABLE OF TRIANGLES

Station	Symbol	Angle		
		Adjusted	Observed (seconds)	Correction (seconds)
		° ′ ″	″	″
Huntingdon	N–6	32 16 47·228	46·556	+ 0·672
Newton	5	79 50 57·998	58·873	− 0·875
Alexandria	8–9	67 52 16·372	16·90	− 0·528
		Sum = 01·598	02·329	
		ϵ = 01·598	Δ closure =	+ 0·731
Newton	–5	169 49 37·064	36·189	+ 0·875
Alexandria	9–10	4 09 37·498	39·18	− 1·682
Rigaud	3	6 00 45·552	45·206	+ 0·346
		Sum = 00·114	00·575	
		ϵ = 0·114	Δ closure =	+ 0·461
Vankleek	27–26	26 37 09·048	08·18	+ 0·868
Newton	–4	96 56 40·193	40·959	− 0·766
Rigaud	1	56 26 11·588	12·136	− 0·548
		Sum = 00·829	01·275	
		ϵ = 00·829	Δ closure =	+ 0·446
Alexandria	10–11	59 04 30·303	29·01	+ 1·293
Vankleek	28–26	70 30 05·527	06·17	− 0·643
Rigaud	1–3	50 25 26·036	26·93	− 0·894
		Sum = 01·866	02·11	
		ϵ = 01·866	Δ closure =	+ 0·244
Alexandria	9–11	63 14 07·801	08·19	− 0·389
Vankleek	28–29	43 52 56·479	57·99	− 1·511
Newton	4–5	72 52 56·871	55·23	+ 1·641
		Sum = 01·151	01·41	
		ϵ = 01·151	Δ closure =	+ 0·259
Bonville	14–15	49 18 33·620	33·51	+ 0·110
Alexandria	13–8	100 57 51·476	50·98	+ 0·496
Huntingdon	6–7H	29 43 36·945	38·76	− 1·815
		Sum = 02·041	03·25	
		ϵ = 02·041	Δ closure =	+01·209
Maxville	20–21	40 49 20·074	19·69	+ 0·384
Vankleek	29–26	103 17 26·936	26·28	+ 0·656
Rigaud	1–2	35 53 14·913	15·88	− 0·967
		Sum = 01·923	01·85	
		ϵ = 01·923	Δ closure =	− 0·073
Maxville	19–21	73 48 00·918	00·87	+ 0·048
Vankleek	29–28	32 47 21·409	20·11	+ 1·299
Alexandria	11–12	73 24 38·635	38·45	+ 0·185
		Sum = 0·962	59·43	
		ϵ = 0·962	Δ closure =	−01·532
Bonville	15–16	40 01 03·884	03·75	+ 0·134
Alexandria	12–13	54 31 05·716	05·48	+ 0·236
Maxville	25–19	85 27 51·114	50·53	+ 0·584
		Sum = 0·714	59·76	
		ϵ = 0·714	Δ closure =	− 0·954

TABLE OF TRIANGLES—*Continued*

Station	Symbol	Angle		
		Adjusted	Observed (seconds)	Correction (seconds)
		° ′ ″	″	″
Rigaud	2–3	14 32 11·123	11·05	+ 0·073
Alexandria	10–12	132 29 08·938	07·46	+ 1·478
Maxville	19–20	32 58 40·844	41·18	− 0·336
		Sum = 0·905	59·69	
		ϵ = 0·905	Δ closure =	−01·215
Huntingdon	6–7	7 12 34·785	34·49	+ 0·295
Alexandria	12–8	155 28 57·192	56·46	+ 0·732
Maxville	18–19	17 18 28·579	27·52	+ 1·059
		Sum = 0·556	58·47	
		ϵ = 0·556	Δ closure =	− 2·086
Huntingdon	7–7H	22 31 02·160	04·27	− 2·110
Bonville	14–16	89 19 37·504	37·26	+ 0·244
Maxville	25–18	68 09 22·535	23·01	− 0·475
		Sum = 02·199	04·54	
		ϵ = 02·199	Δ closure =	+02·341
Plantagenet	31–30	52 04 46·596	47·26	− 0·664
Maxville	21–22	65 20 58·670	58·46	+ 0·210
Vankleek	29V–29	62 34 16·546	16·78	− 0·234
		Sum = 01·812	02·50	
		ϵ = 01·812	Δ closure =	+ 0·688
Roxboro	43–44	68 28 34·150	34·93	− 0·780
Plantagenet	32–31	33 53 02·497	01·62	+ 0·877
Maxville	22–24	77 38 24·666	25·30	− 0·634
		Sum = 01·313	01·85	
		ϵ = 01·313	Δ closure =	+ 0·537
Navan	38–37	34 15 52·992	52·68	+ 0·312
Plantagenet	33–31	114 18 59·084	58·93	+ 0·154
Maxville	22–23	31 25 09·817	10·90	− 1·083
		Sum = 01·893	02·51	
		ϵ = 01·893	Δ closure =	+ 0·617
Roxboro	42–43	64 12 37·028	36·46	+ 0·568
Maxville	24–25	57 44 44·632	44·84	− 0·208
Bonville	16–17	58 02 39·063	39·48	− 0·417
		Sum = 0·723	00·78	
		ϵ = 0·723	Δ closure =	+ 0·057
Navan	39–37	54 02 01·382	01·75	− 0·368
Plantagenet	33–32	80 25 56·587	57·31	− 0·723
Roxboro	44–45	45 32 04·182	03·91	+ 0·272
		Sum = 02·151	02·97	
		ϵ = 02·150	Δ closure =	+ 0·820
Navan	39–38	19 46 08·390	09·07	− 0·680
Roxboro	43–45	114 00 38·332	38·84	− 0·508
Maxville	23–24	46 13 14·849	14·40	+ 0·449
		Sum = 01·571	02·31	
		ϵ = 01·570	Δ closure =	+ 0·740
Buckingham	35–34	58 03 24·136	23·15	+ 0·986
Plantagenet	33P–33	42 03 13·888	13·48	+ 0·408
Navan	37–36	79 53 23·469	23·22	+ 0·249
		Sum = 01·493	59·85	
		ϵ = 01·494	Δ closure =	+01·644

TABLE OF TRIANGLES—*Concluded*

Station	Symbol	Angle		
		Adjusted	Observed (seconds)	Correction (seconds)
		° ′ ″	″	″
King Mountain	51–52	10 39 14·899	15·77	− 0·871
Plantagenet	.....	14 25 35·503	*not observed*	
Navan	37–41	154 55 10·696	10·63	+ 0·066
		Sum = 01·098		
		ϵ = 01·098		
King Mountain	51–52	23 02 25·618	24·23	+ 1·388
Plantagenet	.....	27 37 38·385	*not observed*	
Buckingham	35B–34	129 19 58·369	57·74	+ 0·629
		Sum = 02·372		
		ϵ = 02·372		
Navan	40–39	68 06 51·495	50·99	+ 0·505
Roxboro	45–45R	60 29 21·414	21·38	+ 0·034
North Mountain	46–47	51 23 50·884	51·27	− 0·386
		Sum = 03·793	03·64	
		ϵ = 03·793	Δ closure =	− 0·153
King Mountain	49–50	14 39 43·163	42·99	+ 0·173
Navan	41–39	151 02 47·922	47·62	+ 0·302
Roxboro	.....	14 17 30·648	*not observed*	
		Sum = 01·733		
		ϵ = 01·733		
King Mountain	48–50	52 49 09·703	10·09	− 0·387
Navan	41–40	82 55 56·427	56·63	− 0·203
North Mountain	47–47M	44 14 57·827	57·79	+ 0·037
		Sum = 03·957	04·51	
		ϵ = 03·957	Δ closure =	+ 0·553
King Mountain	48–49	38 09 26·540	27·10	− 0·560
Roxboro	.....	46 11 50·766	49·06	
North Mountain	46–47M	95 38 48·711	49·06	− 0·349
		Sum = 06·017		
		ϵ = 06·017		
King Mountain	50–52	33 41 40·517	40·00	+ 0·517
Buckingham	35B–35	71 16 34·233	34·59	− 0·357
Navan	36–41	75 01 47·227	47·41	− 0·183
		Sum = 01·977	02·00	
		ϵ = 01·976	Δ closure =	+ 0·024

Comparison of Log Distances

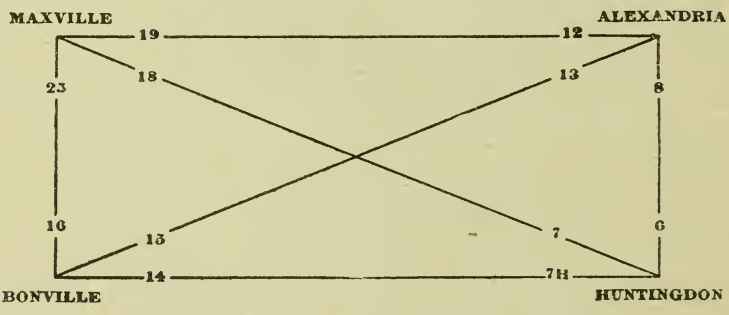
A further check on the accuracy is given by the agreement of the logarithms of the distances computed through different chains of triangles. These results are here tabulated.

Line	Log Distance
King Mountain—Roxboro	4·8620439
" "	4·8620439
King Mountain—North Mountain	4·7225263
" " "	4·7225264
" " "	4·7225263
Roxboro—North Mountain	4·6550151
" "	4·6550151
Bonville—Huntingdon	4·6613835
" "	4·6613834
Bonville—Alexandria	4·3647465
" "	4·3647466
Maxville—Huntingdon	4·6937116
" "	4·6937115
Alexandria—Huntingdon	4·5491897
" "	4·5491899
Alexandria—Newton	4·2836249
" "	4·2836247
Alexandria—Rigaud	4·5105236
" "	4·5105237
Vankleek—Rigaud	4·4695797
" "	4·4695796
Vankleek—Newton	4·3935651
" "	4·3935649
Alexandria—Vankleek	4·4231024
" "	4·4231022
Maxville—Vankleek	4·4222335
" "	4·4222336
" "	4·4222334
" "	4·4222335
Maxville—Rigaud	4·6424025
" "	4·6424025
" "	4·6424024
Maxville—Alexandria	4·1743361
" "	4·1743360
" "	4·1743359
Maxville—Bonville	4·2768931
" "	4·2768932
" "	4·2768932
Plantagenet—Vankleek	4·4837333
Plantagenet—Maxville	4·4734406
Roxboro—Maxville	4·2510888
Roxboro—Plantagenet	4·4946498
" "	4·4946499

COMPARISON OF LOG DISTANCES—*Concluded.*

Line.	Log Distance
Roxboro—Bonville	4·2496691
" "	4·2496694
Navan—Plantagenet	4·4400051
" "	4·4400050
Navan—Maxville	4·6825757
" "	4·6825759
Navan—Roxboro	4·5804241
" "	4·5804242
Buckingham—Plantagenet	4·5045202
Buckingham—Navan	4·3372797
King Mountain—Plantagenet	4·8003730
" " "	4·8003730
Navan—North Mountain	4·6271506
King Mountain—Navan	4·5695568
" "	4·5695568
" "	4·5695569
" "	4·5695566
King Mountain—Buckingham	4·5781758
" " "	4·5781759
" " "	4·5781759

ANGLE EQUATIONS OF QUADRILATERIALS



I $\Sigma \angle = 25-18+15-16-13+8-6+7 = +1\cdot''290$

II $\Sigma \angle + V\text{'s} = 25-18+14-16+7-7H+(25)-(18)+(14)-(16)+(7)-(7H) = 180°\ 00'\ 02\cdot''199$

III $\Sigma \angle + V\text{'s} = 13-8+6-7H+14-15+(13)-(8)+(6)-(7H)+(14)-(15) = 180°\ 00'\ 02\cdot''041$

Angle Equation $= -I+II-III = (25)-(18)+(15)-(16)-(13)+((8)-(6)+7+1\cdot132 = 0$

I $\Sigma \angle = 14-15+7-7H-12+13-18+19 = +4\cdot780$

II $\Sigma \angle + V\text{'s} = 14-15+6-7H+13-8+(14)-(15)+(6)-(7H)+(13)-(8) = 180°\ 00'\ 02\cdot''041$

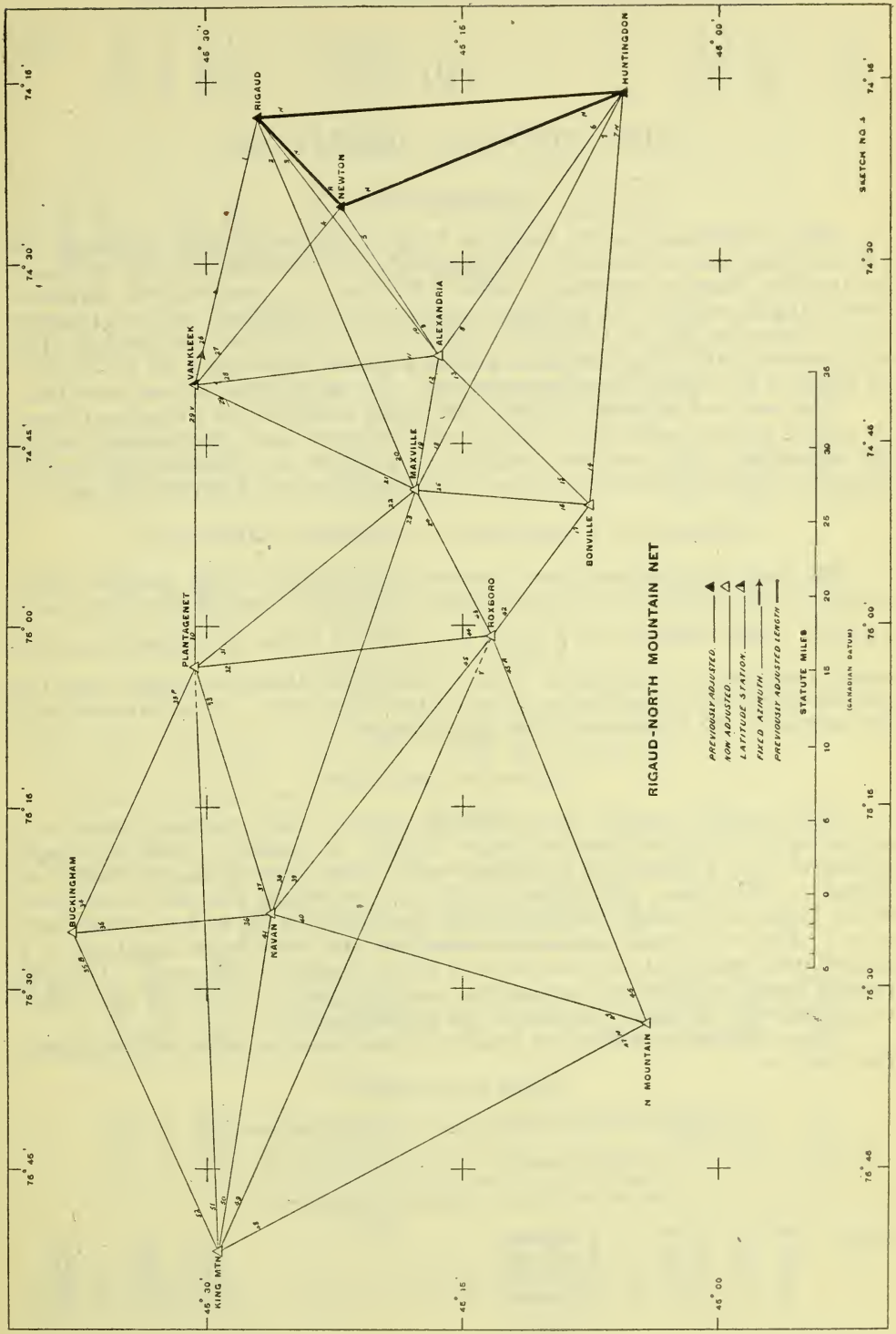
III $\Sigma \angle + V\text{'s} = 18-19+12-8+6-7+(18)-(19)+(12)-(8)+(6)-(7) = 180'\ 00'\ 00\cdot''556$

Angle Equation $= I+II-III = (14)-(15)+(7)-(7H)-(12)+(13)-(18)+(19)+3\cdot295 = 0$

$\Sigma \angle = 6-7H+12-8+25-19+14-16 = 360°\ 00'\ 03\cdot''010$

$\Sigma \angle + V\text{'s} = 6-7H+12-8+25-19+14-16+(6)-(7H)+(12)-(8)+(25)-(19)+(14)-(16) = 360°\ 00'\ 02\cdot''755$

Angle Equation $= (6)-(7H)+(12)-(8)+(25)-(19)+(14)-(16)+0\cdot255 = 0$


RIGAUD
NEWTON
HUNTINGDON
VANKLEEK
ALEXANDRIA
MAXVILLE
BONVILLE
PLANTAGENET
FOXBORO
BUCKINGHAM
KAVAN
KING MTN
N MOUNTAIN
RIGAUD-NORTH MOUNTAIN NET
PREVIOUSLY ADJUSTED
NOW ADJUSTED
LATITUDE STATION
FIXED AZIMUTH
PREVIOUSLY ADJUSTED LENGTH
STATUTE MILES
(CANADIAN DATUM)
SKETCH NO. 4

VIII

KING MOUNTAIN—MURRAY NET

Introduction

This net is based on the fixed line King Mountain to North Mountain, as obtained from the adjustment of the Rigaud-North Mountain net, and concludes on the line Murray–Grimsthorpe some 130 miles in a southwesterly direction from King Mountain. It embraces twenty-seven conditions, and was founded on the Canadian datum, i.e. on an observed φ 45° 30′ 36.99″ at Vankleek Hill, an observed a 102° 38′ 10.84″ from Vankleek Hill to Royal and λ 73° 35′ 25.197″ of Royal as per United States geodetic net. For map of this net see page 164.

This net is of primary accuracy, but being based on the Canadian datum, its results are only preliminary, and the chief interest lies in the methods used in the adjustment. It was later included in a larger net, Dusable–Haldimand, based on the North American datum, a description of which appears on page 11.

Preliminary Corrections to Observed Directions

All observed directions were corrected for altitude of the stations above mean sea level and reduced to the geodetic line by the formulæ $108'' \cos^2\varphi \sin 2ah$ and $-.028'' \cos^2 \sin 2a \left(\frac{d}{100}\right)^2$ respectively. These corrections were very small, resulting in a maximum of only 0.016″ and therefore smaller than the probable error of a direction as given by the adjustment. This correction will be omitted in the future except for high altitudes.

Condition Equations

The direction method was employed and the side equations picked out according to the plan given on pages 233-242* of Jordan 1, while the angle equations were also selected according to the ideas given on pages 249-252* of Jordan 1. This plan, while giving ideally the best results will not be continued in the future as it entails too much work, especially for big systems which may occur. Hence in future 6-term side equations and three angle equations of a quadrilateral selected from the closure of three triangles will be used. This will greatly lessen the work in solving the normal equations, and will more than compensate for the slight decrease in the probable error.

The condition equations are detailed in the following order, side equations first, viz.:—

SIDE EQUATIONS

(Kaladar)–Olden–Portland–Tyendinaga–Grimsthorpe

$$\frac{\sin 35-34 \sin 40-41 \sin 48-47 \sin 55-54}{\sin 39-40 \sin 44-48 \sin 56-55 \sin 36-35} = 1$$

	°	′	″				
log sin	90	40	33·69	=	9·9999698	− 0·2 (35) − (34)	
"	43	25	24·33	=	9·8371998	22·2 (40) − (41)	
"	30	00	13·67	=	9·6990199	36·5 (48) − (47)	
"	23	15	36·05	=	9·5964920	49·0 (55) − (54)	
				=	9·1326815		

* Vermessungskunde, Jordan, Vol. 1, 5th. edition.

(Kaladar)–Olden–Portland–Tyendinaga–Grimsthorpe—*Continued.*

log sin	35	13	13·11	=	9·7609664	29·8	(39)	– (40)
"	69	06	15·27	=	9·9704542	8·0	(44)	– (48)
"	48	43	54·86	=	9·8760050	18·5	(56)	– (55)
"	19	34	58·25	=	9·5252645	59·2	(36)	– (35)
				=	9·1326901			
					– 86			

+0·02 (34)	+5·90 (35)	−5·92 (36)	−2·98 (39)	+5·20 (40)	
−2·22 (41)	−0·80 (44)	−3·65 (47)	+4·45 (48)	−4·90 (54)	
+6·75 (55)	−1·85 (56)				−8·60 = 0

Forming Normal Equation No. 1

$\Sigma = 217{\cdot}4656$

(Olden)–Lavant–N. Crosby–Portland–Kaladar

$$\frac{\sin 17-16 \sin 30-29 \sin 39-40 \sin 49-53}{\sin 31-30 \sin 38-39 \sin 50-49 \sin 17La-17} = 1$$

	°	′	″					
log sin	46	53	06·05	=	9·8633131	19·7	(17)	– (16)
"	70	34	43·43	=	9·9745574	7·4	(30)	– (29)
"	35	13	13·11	=	9·7609664	29·8	(39)	– (40)
"	25	34	14·35	=	9·6351053	44·0	(49)	– (53)
				=	9·2339422			
"	54	15	59·38	=	9·9094181	15·1	(31)	– (30)
"	54	46	20·83	=	9·9121517	14·9	(38)	– (39)
"	54	06	14·87	=	9·9085300	15·2	(50)	– (49)
"	18	36	19·48	=	9·5038571	62·5	(17*La*)	– (17)
				=	9·2339569			
					−147			

−1·97 (16)	+8·22 (17)	−6·25 (17*La*)	−0·74 (29)	+2·25 (30)	
−1·51 (31)	−1·49 (38)	+4·47 (39)	−2·98 (40)	+5·92 (49)	
−1·52 (50)	−4·40 (53)				−14·7 = 0

Forming Normal Equation No. 2

$\Sigma = 206{\cdot}2002$

(Centre)–Lavant–N. Elmsley–Bastard–N. Crosby

$$\frac{\sin 12-59 \sin 21-20 \sin 26-31 \sin 15-14}{\sin 22-21 \sin 27-26 \sin 16-15 \sin 11-12} = 1$$

	°	′	″					
log sin	42	40	58·81	=	9·8311922	22·8	(12)	– (59)
"	40	39	43·80	=	9·8139796	24·5	(21)	– (20)
"	65	20	09·00	=	9·9584537	9·7	(26)	– (31)
"	29	30	05·15	=	9·6923580	37·2	(15)	– (14)
				=	9·2959835			
"	46	31	30·46	=	9·8607429	20·0	(22)	– (21)
"	50	07	50·10	=	9·8850826	17·6	(27)	– (26)
"	23	52	20·22	=	9·6071325	47·6	(16)	– (15)
"	61	17	29·12	=	9·9430363	11·5	(11)	– (12)
				=	9·2959943			
					−108			

−1·15 (11)	+3·43 (12)	−3·72 (14)	+8·48 (15)	−4·76 (16)	
−2·45 (20)	+4·45 (21)	−2·00 (22)	+2·73 (26)	−1·76 (27)	
−0·97 (31)	−2·28 (59)				−10·80 = 0

Forming Normal Equation No. 3

$\Sigma = 167{\cdot}9886$

(N. Crosby)–Lavant–Bastard–Lansdowne–Portland–Olden

$$\frac{\sin 16-15 \sin 20-19 \sin 25-25La \sin 38-39 \sin 33-32}{\sin 21-20 \sin 24-25 \sin 37-38 \quad \sin 34-35 \sin 17-16} = 1$$

	°	′	″					
log sin	23	52	20·22	=	9·6071325	47·6	(16) –	(15)
"	109	28	38·64	=	9·9744073	– 7·4	(20) –	(19)
"	39	22	09·64	=	9·8023063	25·7	(25) –	(25*La*)
"	54	46	20·83	=	9·9121517	14·9	(38) –	(39)
"	78	50	58·92	=	9·9917236	4·2	(33) –	(32)
				=	9·2877214			
"	40	39	43·80	=	9·8139796	24·5	(21) –	(20)
"	39	13	36·92	=	9·8009873	25·8	(24) –	(25)
"	52	14	20·89	=	9·8979423	16·3	(37) –	(38)
"	54	38	58·97	=	9·9114932	14·9	(34) –	(33)
"	46	53	06·05	=	9·8633131	19·7	(17) –	(16)
				=	9·2877155			
					+ 59			

– 4·76 (15)	+ 6·73 (16)	– 1·97 (17)	+ 0·74 (19)	+ 1·71 (20)		
– 2·45 (21)	– 2·58 (24)	+ 5·15 (25)	– 2·57 (25*La*)	– 0·42 (32)		
+ 1·91 (33)	– 1·49 (34)	– 1·63 (37)	+ 3·12 (38)	– 1·49 (39)	+ 5·90	= 0

Forming Normal Equation No. 4

$\Sigma = 141{\cdot}7454$

(Bastard)–N. Elmsley–Elizabethtown–Lansdowne–N. Crosby

$$\frac{\sin 6-7 \cdot \sin 23-24 \sin 28-27 \sin 12-59}{\sin 7-7E \sin 24-25 \sin 27-26 \sin 59-8} = 1$$

	°	′	″					
log sin	44	53	23·11	=	9·8486477	21·1	(6) –	(7)
"	65	36	20·57	=	9·9593872	9·5	(23) –	(24)
"	31	17	46·14	=	9·7155534	34·6	(28) –	(27)
"	42	40	58·81	=	9·8311922	22·8	(12) –	(59)
				=	9·3547805			
"	42	11	46·28	=	9·8271568	23·2	(7) –	(7E)
"	39	13	36·92	=	9·8009873	25·8	(24) –	(25)
"	50	07	50·10	=	9·8850826	17·6	(27) –	(26)
"	43	58	26·23	=	9·8415667	21·8	(59) –	(8)
				=	9·3547934			
					– 129			

+ 2·11 (6)	– 4·43 (7)	+ 2·32 (7E)	+ 2·18 (8)	+ 2·28 (12)		
+ 0·95 (23)	– 3·53 (24)	+ 2·58 (25)	+ 1·76 (26)	– 5·22 (27)		
+ 3·46 (28)	– 4·46 (59)				– 12·90	= 0

Forming Normal Equation No. 5

$\Sigma = 121{\cdot}6392$

(North Elmsley)–King Mountain–North Mountain–Elizabethtown–Bastard–Lavant

$$\frac{\sin 2-2K \sin 4-4M \sin 6-7 \sin 22-21 \sin 14-13}{\sin 3-4 \quad \sin 5-6 \quad \sin 18-22 \sin 15-14 \sin 1-2} = 1$$

		°	′	″					
log sin		46	00	56·695	=	9·8570493	20·3	(21)	− (2K)
"	+	58	40	01·96	=	9·9315400	+ 12·8	(4)	− (4M)
"		44	53	23·11	=	9·8486477	21·1	(6)	− (7)
"		46	31	30·46	=	9·8607429	20·0	(22)	− (21)
"		49	36	49·92	=	9·8817811	17·9	(14)	− (13)
						9·3797610			
"	+	77	04	47·824	=	9·9888634	+ 4·8	(3)	− (4)
"		62	10	51·83	=	9·9466619	11·1	(5)	− (6)
"		91	08	12·50	=	9·9999145	− 0·4	(18)	− (22)
"		29	30	05·15	=	9·6923580	37·2	(15)	− (14)
"		34	23	42·974	=	9·7519707	30·8	(1)	− (2)
					=	9·3797685			
						− 75			

− 3·08 (1) + 5·11 (2) − 2·03 (2K) − 0·48 (3) + 1·76 (4)
− 1·28 (4M) − 1·11 (5) + 3·22 (6) − 2·11 (7) − 1·79 (13)
+ 5·51 (14) − 3·72 (15) + 0·04 (18) − 2·00 (21) + 1·96 (22) − 7·50 = 0

Forming Normal Equation No. 6

$\Sigma = 115{\cdot}9842$

(Tyendinaga)–Kaladar–Portland–Hallowell–Murray–Grimsthorpe

$$\frac{\sin 40-41 \quad \sin 42-43 \sin 58-58M_{II} \sin 56G-56 \sin 52-51 \sin}{\sin 41-41P \sin 43-43H \sin 58-57 \quad \sin 56-55 \sin 51-50 \sin} = 1$$

		°	′	″					
log sin		43	25	24·33	=	9·8371998	22·2	(40)	− (41)
"		52	35	59·04	=	9·9000457	16·1	(42)	− (43)
"		44	55	07·31	=	9·8488678	21·1	($58M_{II}$)	− (58)
"		39	56	14·12	=	9·8075002	25·1	(56G)	− (56)
"		101	15	54·36	=	9·9915512	− 4·2	(52)	− (51)
						9·3861647			
"		36	22	48·95	=	9·7731584	28·6	(41)	− (41P)
"		64	29	52·37	=	9·9554806	10·0	(43)	− (43H)
"		40	46	38·22	=	9·8149933	24·4	(58)	− (57)
"		48	43	54·86	=	9·8760050	18·5	(56)	− (55)
"		67	28	24·14	=	9·9655317	8·7	(51)	− (50)
					=	9·3851690			
						− 43			

+ 2·22 (40) − 5·08 (41) + 2·86 (41P) + 1·61 (42) − 2·61 (43)
+ 1·00 (43H) + 0·87 (50) − 0·45 (51) − 0·42 (52) + 1·85 (55)
− 4·36 (56) + 2·51 (56G) + 2·44 (57) − 4·55 (58) + 2·11 ($58M_{II}$) −4·30 = 0

Forming Normal Equation No. 7

$\Sigma = 110{\cdot}2948$

ANGLE EQUATIONS OF TRIANGLES

$\Sigma \angle_{\circ} = (2-2K) + (3-4) + (9-10)$ = 180° 00′ 07·499″
" + v's = + v's − 180° 00′ 05·912″ = 0
Angle Eq. (2) − (2K) + (3) − (4) + (9) − (10) +01·587 = 0

$\Sigma \angle_{\circ} = (1-2) + (10-11) + (14-13)$ = 180° 00′ 06·584″
" + v's = + v's − 180° 00′ 07·051″ = 0
Angle Eq. (1) − (2) + (10) − (11) − (13) + (14) − 0·467 = 0

$\Sigma \angle_{\circ} = (4-4M) + (5-6) + (8-9)$ = 180° 00′ 02·96″
" + v's = + v's − 180° 00′ 04·320″ = 0
Angle Eq. (4) − (4M) + (5) − (6) + (8) − (9) − 01·360 = 0

$\Sigma \angle_o = (6-7) + (59-8) + (18-22) \ldots = 180° 00' 01{\cdot}84''$
" $+ v's = + v's \ldots - 180° 00' 02{\cdot}382'' = 0$
Angle Eq. (6) − (7) − (8) + (18) − (22) + (59) − 0·542 $= 0$

$\Sigma \angle_o = (7-7E) + (19-18) + (23-24) \ldots = 180° 00' 01{\cdot}45''$
" $+ v's = v's \ldots - 180° 00' 01{\cdot}646'' = 0$
Angle Eq. (7) − (7*E*) − (18) + (19) + (23) − (24) −0·196 $= 0$

$\Sigma \angle_o = (20-19) + (24-25) + (28-27) \ldots = 180° 00' 01{\cdot}70''$
" $+ v's = + v's \ldots - 180° 00' 01{\cdot}433'' = 0$
Angle Eq. (19) + (20) + (24) − (25) − (27) + (28) + 0·237 $= 0$

$\Sigma \angle_o = (25-25La) + (29-28) + (37-38) \ldots = 180° 00' 02{\cdot}48''$
" $+ v's = + v's \ldots - 180° 00' 03{\cdot}368'' = 0$
Angle Eq. (25) − (25*La*) − (28) + (29) + (37) − (38) − 0·888 $= 0$

$\Sigma \angle_o = (30-29) + (34-33) + (38-39) \ldots = 180° 00' 03{\cdot}23''$
" $+ v's = + v's \ldots - 180° 00' 02{\cdot}553'' = 0$
Angle Eq. − (29) + (30) − (33) + (34) + (38) − (39) + 0·677 $= 0$

$\Sigma \angle_o = (17-16) + (31-30) + (33-32) \ldots = 180° 00' 04{\cdot}35''$
" $+ v's = + v's \ldots - 180° 00' 02{\cdot}958'' = 0$
Angle Eq. − (16) + (17) − (30) + (31) − (32) + (33) + 1·392 $= 0$

$\Sigma \angle_o = (35-34) + (39-40) + (50-49) \ldots = 180° 00' 01{\cdot}67''$
" $+ v's = + v's \ldots - 180° 00' 02{\cdot}573'' = 0$
Angle Eq. − (34) + (35) + (39) − (40) − (49) + (50) − 0·903 $= 0$

$\Sigma \angle_o = (40-41) + (44-48) + (51-50) \ldots = 180° 00' 03{\cdot}74''$
" $+ v's = + v's \ldots - 180° 00' 03{\cdot}743'' = 0$
Angle Eq. (40) − (41) + (44) − (48) − (50) + (51) − 0·003 $= 0$

$\Sigma \angle_o = (41-41P) + (42-43) + (45-44) \ldots = 180° 00' 03{\cdot}45''$
" $+ v's = + v's \ldots - 180° 00' 04{\cdot}020'' = 0$
Angle Eq. (41) − (41*P*) + (42) − (43) − (44) + (45) − 0·570 $= 0$

$\Sigma \angle_o = (47-46) + (58-57) + (56G-56) \ldots = 180° 00' 05{\cdot}02''$
" $+ v's = + v's \ldots - 180° 00' 04{\cdot}924'' = 0$
Angle Eq. − (46) + (47) − (56) + (56*G*) − (57) + (58) + 0·096 $= 0$

$\Sigma \angle_o = (48-47) + (52-51) + (56-55) \ldots = 180° 00' 02{\cdot}89''$
" $+ v's = + v's \ldots - 180° 00' 01{\cdot}945'' = 0$
Angle Eq. − (47) + (48) − (51) + (52) − (55) + (56) + 0·945 $= 0$

$\Sigma \angle_o = (46-45) + (43-43H) + (58My-58) \ldots = 180° 00' 02{\cdot}60''$
" $+ v's = + v's \ldots - 180° 00' 03{\cdot}619'' = 0$
Angle Eq. (43) − (43*H*) − (45) + (46) − (58) + (58*My*) − 1·019 $= 0$

$\Sigma \angle_o = (17La-17) + (32-35) + (49-53) \ldots = 180° 00' 02{\cdot}25''$
" $+ v's = + v's \ldots - 180° 00' 01{\cdot}727'' = 0$
Angle Eq. (17) + (17*La*) + (32) − (35) + (49) − (53) + 0·523 $= 0$

$\Sigma \angle_o = (36-35) + (49-52) + (55-54) \ldots = 180° 00' 00{\cdot}93''$
" $+ v's = + v's \ldots - 180° 00' 01{\cdot}057'' = 0$
Angle Eq. − (35) + (36) + (49) − (52) − (54) + (55) − 0·127 $= 0$

ANGLE EQUATIONS OF QUADRILATERALS

$\Sigma \pm \angle_o = (11-12) + (15) - (14) - (21-20) - (27-26) \ldots = 0{\cdot}37$
$\Sigma \angle_o + v's$ of △ Lavant–North Elmsley–Bastard $\ldots = 180° 00' 3{\cdot}463''$
$\Sigma \angle_o + v's$ of △ North Crosby $\ldots = 180° 00' 2{\cdot}137''$
Angle Eq. $= 1 + 2 \sim 3 = (11) - (12) - (14) + (15) + (20) - (21)$
$+ (26) - (27) \ldots - 0{\cdot}956 = 0$

$\Sigma \pm \angle_o = (15-16) + (26-31) - (12-59) - (22-21) \ldots = -0{\cdot}05$
$\Sigma \angle_o + v's$ of △ Lavant–Crosby–Bastard $\ldots = 180° 00' 02{\cdot}747''$
$\Sigma \angle_o + v's$ of △ North Crosby–Bastard–Elmsley $\ldots = 180° 00' 02{\cdot}137''$
Angle Eq. $= 1 + 2 \sim 3 = (12) - (15) + (16) + (21) - (22) + (26)$
$- (31) + (59) \ldots - 0{\cdot}660 = 0$

$\Sigma \pm \angle_o = (11-59) + (22-20) + (27-31) + (16-14) \ldots = 360° 00' 06{\cdot}66''$
$\Sigma \angle_o + v's = + v's \ldots = 360° 00' 06{\cdot}210''$
Angle Eq. $= (11) - (14) + (16) - (20) + (22) + (27) - (31) - (59) \ldots + 0{\cdot}450 = 0$

Summaries of the Condition Equations

The condition equations are here collected, the first seven being side equations and the last twenty being angle equations.

CONDITION EQUATIONS

1. $0{\cdot}02\ (34) + 5{\cdot}90\ (35) - 5{\cdot}92\ (36) - 2{\cdot}98\ (39) + 5{\cdot}20\ (40) - 2{\cdot}22\ (41) - 0{\cdot}80\ (44)$
$4{\cdot}45\ (48) - 3{\cdot}65\ (47) - 4{\cdot}90\ (54) + 6{\cdot}75\ (55) - 1{\cdot}85\ (56) - 8{\cdot}60 = 0$

2. $-1{\cdot}97\ (16) + 8{\cdot}22\ (17) - 6{\cdot}25\ (17\text{La}) - {\cdot}74\ (29) + 2{\cdot}25\ (30) - 1{\cdot}51\ (31) - 1{\cdot}49\ (38)$
$+ 4{\cdot}47\ (39) - 2{\cdot}98\ (40) + 5{\cdot}92\ (49) - 1{\cdot}52\ (50) - 4{\cdot}40\ (53) - 14{\cdot}70 = 0$

3. $- 1{\cdot}15\ (11) + 3{\cdot}43\ (12) - 3{\cdot}72\ (14) + 8{\cdot}48\ (15) - 4{\cdot}76\ (16) - 2{\cdot}45\ (20) + 4{\cdot}45\ (21)$
$- 2{\cdot}00\ (22) + 2{\cdot}73\ (26) - 1{\cdot}76\ (27) - 0{\cdot}97\ (31) - 2{\cdot}28\ (59) - 10{\cdot}80 = 0$

4. $- 4{\cdot}76\ (15) + 6{\cdot}73\ (16) - 1{\cdot}97\ (17) + 0{\cdot}74\ (19) + 1{\cdot}71\ (20) - 2{\cdot}45\ (21) - 2{\cdot}58\ (24)$
$+ 5{\cdot}15\ (25) - 2{\cdot}57\ (25\text{La}) - 0{\cdot}42\ (32) + 1{\cdot}91\ (33) - 1{\cdot}49\ (34) - 1{\cdot}63\ (37) + 3{\cdot}12\ (38)$
$- 1{\cdot}49\ (39) + 5{\cdot}90 = 0$

5. $+ 2{\cdot}11\ (6) - 4{\cdot}43\ (7) + 2{\cdot}32\ (7\text{E}) + 2{\cdot}18\ (8) + 2{\cdot}28\ (12) + 0{\cdot}95\ (23) - 3{\cdot}53\ (24)$
$+ 2{\cdot}58\ (25) + 1{\cdot}76\ (26) - 5{\cdot}22\ (27) + 3{\cdot}46\ (28) - 4{\cdot}46\ (59) - 12{\cdot}90 = 0$

6. $- 3{\cdot}08\ (") + 5{\cdot}11\ (2) - 2{\cdot}03\ (2\text{K}) - 0{\cdot}48\ (3) + 1{\cdot}76\ (4) - 1{\cdot}28\ (4\text{M}) - 1{\cdot}11\ (5) + 3{\cdot}22$
$(6) - 2{\cdot}11\ (7) - 1{\cdot}79\ (13) + 5{\cdot}51\ (14) - 3{\cdot}72\ (15) + 0{\cdot}04\ (18) - 2{\cdot}00\ (21) + 1{\cdot}96\ (22)$
$- 7{\cdot}50 = 0$

7. $+ 2{\cdot}22\ (40) - 5{\cdot}08\ (41) + 2{\cdot}86\ (41\text{P}) + 1{\cdot}61\ (42) - 2{\cdot}61\ (43) + 1{\cdot}00\ (43\text{H}) + 0{\cdot}87\ (50)$
$- 0{\cdot}45\ (51) - 0{\cdot}42\ (52) + 1{\cdot}85\ (55) - 4{\cdot}36\ (56) + 2{\cdot}51\ (56\text{G}) + 2{\cdot}44\ (57) - 4{\cdot}55\ (58)$
$+ 2{\cdot}11\ (58\text{My}) - 4{\cdot}30 = 0$

8. $(11) - (14) + (16) - (20) + (22) + (27) - (31) - (59) + 0{\cdot}450 = 0$

9. $(11) - (12) - (14) + (15) + (20) - (21) + (26) - (27) - 0{\cdot}956 = 0$

10. $- (12) - (15) + (16) + (21) - (22) + (26) - (31) + (59) - 0{\cdot}660 = 0$

11. $- (17) + (17\text{La}) + (32) - (35) + (49) - (53) + 0{\cdot}523 = 0$

12. $- (35) + (36) + (49) - (52) - (54) + (55) - 0{\cdot}127 = 0$

13. $(2) - (2\text{K}) + (3) - (4) + (9) - (10) + 1{\cdot}587 = 0$

14. $(1) - (2) + (10) - (11) - (13) + (14) - 0{\cdot}467 = 0$

15. $(4) - (4\text{M}) + (5) - (6) + (8) - (9) - 1{\cdot}360 = 0$

16. $(6) - (7) - (8) + (18) - (22) + (59) - 0{\cdot}542 = 0$

17. $(7) - (7\text{E}) - (18) + (19) + (23) - (24) - 0{\cdot}196 = 0$

18. $- (19) + (20) + (24) - (25) - (27) + (28) + 0{\cdot}237 = 0$

19. $(25) - (25\text{La}) - (28) + (29) + (37) - (38) - 0{\cdot}888 = 0$

20. $- (29) + (30) - (33) + (34) + (38) - (39) + 0{\cdot}677 = 0$

21. $- (16) + (17) - (30) + (31) - (32) + (33) + 1{\cdot}392 = 0$

22. $- (34) + (35) + (39) - (40) - (49) + (50) - 0{\cdot}903 = 0$

23. $(40) - (41) + (44) - (48) - (50) + (51) - 0{\cdot}003 = 0$

24. $(41) - (41\text{P}) + (42) - (43) - (44) + (45) - 0{\cdot}570 = 0$

25. $- (46) + (47) - (56) + (56\text{G}) - (57) + (58) + 0{\cdot}096 = 0$

26. $- (47) + (48) - (51) + (52) - (55) + (56) + 0{\cdot}945 = 0$

27. $(43) - (43H) - (45) + (46) - (58) + (58My) - 1{\cdot}019 = 0$

Correlate Equations

The correlate equations are formed by recording the terms of condition No. 1 in the K_1 column, condition No. 2 in the K_2 column, etc., on the line opposite the respective number of their direction in the left-hand column.

Direction No.	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	Sum
1						− 3·08								+1														− 2·08
2						+ 5·11							+1	−1														+ 5·11
2K						− 2·03							−1															− 3·03
3						− 0·48							+1															+ 0·52
4						+ 1·76							−1		+1													+ 1·76
4M						− 1·28									−1													− 2·28
5						− 1·11									+1	+1												− 0·11
6					+ 2·11	+ 3·22									−1	+1												+ 5·33
7					− 4·43	− 2·11										−1	+1											− 6·54
7E					+ 2·32												−1											+ 1·32
8					+ 2·18										+1	−1												+ 2·18
9													+1		−1													0·00
10													−1	+1														0·00
11			− 1·15					+1	+1					−1														− 0·15
12			+ 3·43		+ 2·28				−1	−1																		+ 3·71
13						− 1·79								−1														− 2·79
14			− 3·72			+ 5·51		−1	−1					+1														+ 0·79
15			+ 8·48	− 4·76		− 3·72			+1	−1																		0·00
16		− 1·97	− 4·76	+ 6·73				+1		+1											−1							+ 1·00
17		+ 8·22		− 1·97							−1										+1							+ 6·25
17La		− 6·25									+1																	− 5·25
18						+ 0·04										+1	−1											+ 0·04
19				+ 0·74													+1	−1										+ 0·74
20			− 2·45	+ 1·71				−1	+1									+1										+ 0·26
21			+ 4·45	− 2·45		− 2·00			−1	+1																		0·00
22			− 2·00			+ 1·96		+1		−1						−1												− 1·04
23					+ 0·95												+1											+ 1·95
24				− 2·58	− 3·53												−1	+1										− 6·11
25				+ 5·15	+ 2·58													−1	+1									+ 7·75
25Ln				− 2·57															−1									− 3·57
26			+ 2·73		+ 1·76					+1	+1																	+ 6·49
27			− 1·76		− 5·22			+1	−1									−1										− 7·98
28					+ 3·46													+1	−1									+ 3·46
29		− 0·74																	+1	−1								− 0·74
30		+ 2·25																		+1	−1							+ 2·25
31		− 1·51	− 0·97					−1		−1											+1							− 3·48
32				− 0·42							+1										−1							− 0·42
33				+ 1·91																−1	+1							+ 1·91
34	+ 0·02			− 1·49																+1		−1						− 1·47
35	+ 5·90										−1	−1										+1						+ 4·90
36	− 5·92											+1																− 4·22
37				− 1·63															+1									− 0·63
38		− 1·49		+ 3·12															−1	+1								+ 1·63
39	− 2·98	+ 4·47		− 1·49																−1		+1						0·00
40	+ 5·20	− 2·98					+ 2·22															−1	+1					+ 4·44
41	− 2·22						− 5·08																−1	+1				− 7·30

| | | |

Normal Equations

The order of arrangement of the normal equations is such that the sum of the squares of the coefficients of the conditions equation is in decreasing order of magnitude from first to last, i.e. in the normal equations the diagonal coefficients decrease from left to right. This order of arrangement, while giving the sharpest possible solution, will also be discontinued in the future on account of the increase of work involved. By placing the angle equations first and the side equations last in the correlate equations the diagonal coefficients of the normal equations increase from left to right. This will greatly lessen the work in solving the normal equations and give results which cannot differ materially from that obtained by the former method of arranging the diagonal.

The formation of the normal equations is next shown.

NORMAL EQUATIONS.

K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}	K_{11}	K_{12}	K_{13}	K_{14}	K_{15}
	+0·1325111		−·0202809			−0·1994573				+0·0271307	+0·0007817			
+0·2174656	−0·288166	0	+4·4104	0	0	+43·3751	0	0	0	− 5·9000	− 0·1700	0	0	0
	+206·2002	+ 10·8419	− 40·7606	0	0	− 7·9380	− 0·4600	0	− 0·4600	− 4·1500	+ 5·9200	0	0	0
	− 3·81852	0	− 0·58443			+ 0·574768	0		0	− 0·78181	−0 ·02253			
		+167·9886	− 87·4916	+ 31·9812	− 64·8628	0	− 0·2500	+ 5·2100	− 8·8000	0	0	0	− 2·5700	0
		0	0	0	0	0	0	0	0				0	
			+141·7454	+ 22·3944	+ 22·6072	0	+ 5·0200	− 0·6000	+ 9·0400	+ 1·5500	0	0	0	0
			− 0·08945	0	0	− 0·87969	0	0	0	+ 0·11966	+ 0·00345			
				+121·6392	+ 16·1415	0	− 0·7600	+ 4·7000	− 4·9800	0	0	0	0	+ 0·0700
				0	0	0	0	0	0					0
					+115·9842	0	−3·5500	− 7·2300	− 0·2400	0	0	+ 4·9000	− 0·8900	− 1·2900
					0	0	0	0	0	0	0	0	0	0
						+110·2948	0	0	0	0	+ 2·2700	0	0	0
						− 8·65148				+ 1·17680	+ 0·03391			
							+ 8·0000	0	0	0	0	0	− 2·0000	0
							0						0	
								+ 8·0000	0	0	0	0	− 2·0000	0
								0					0	
									+ 8·0000	0	0	0	0	0
									0					
										+ 6·0000	+ 2·0000	0	0	0
										− 0·16007	− 0·00461			
											+ 6·0000	0	0	0
											− ·00013			
												+ 6·0000	− 2·0000	− 2·0000
												0	0	0
													+ 6·0000	0
													0	
														+ 6·0000

R_{16}	K_{17}	K_{18}	K_{19}	K_{20}	K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{26}	K_{27}	Form—Check.	Absolute Term.	Check.
				−0·0137953		+0·0105764	−0·0099786	+0·0065298	+0·0082772	+0·0022992			+0·0385465	−1·0158595
0	0	0	0	+3·0000	0	−2·3000	+ 2·1700	−1·4200	−1·8000	−0·5000	0	+229·5145	− 8·6000	+220·9145
0	0	0	+ 0·75	− 2·9700	+ 6·4300	− 0·0100	− 1·4600	0	0	0	0	+143·1369	− 14·70	+128·4369
			0	+ 0·39753	0	− 0·30478	+ 0·28755	− 0·18817	− 0·23852	− 0·06626			− 1·13960	+ 29·27362
− 0·2800	0	− 0·06900	0	0	+ 3·7900	0	0	0	0	0	0	+ 54·8673	− 10·8000	+ 44·0673
0		0			0								0	0
0	+ 3·3200	− 6·7600	+ 2·9700	+ 1·2100	− 6·3700	0	0	0	0	0	0	+ 72·2852	+ 5·9000	+ 78·1852
	0			− 0·06084	0	+ 0·04665	− 0·04401	+ 0·02880	+ 0·03651	+ 0·01014			+ 0·17442	− 4·48035
− 0·1000	− 2·2700	+ 2·5700	− 0·8800	0	0	0	0	0	0	0	0	+190·5063	− 12·90000	+177·6063
0	0	0	0										0	0
+ 3·4100	− 2·1500	0	0	0	0	0	0	0	0	0	0	+ 82·8301	− 7·5000	+ 75·3301
0	0	0	0	0	0	0	0	0	0	0			0	0
0	0	0	0	0	0	− 1·3500	+ 5·9800	− 3·7200	− 0·1200	− 6·1800	+ 3·0500	+145·6619	− 4·3000	+141·3619
				− 0·59837		+ 0·45875	− 0·43282	+ 0·28323	+ 0·35902	+ 0·09973	0	0	+ 1·71533	− 44·06303
− 2·0000	0	− 2·0000	0	0	− 2·0000	0	0	0	0	0	0	0	+ 0·4500	+ 0·4500
0		0			0								0	0
0	0	+ 2·0000	0	0	0	0	0	0	0	0	0	+ 10·0800	− 0·9560	+ 9·1240
		0											0	0
+ 2·0000	0	0	0	0	− 2·0000	0	0	0	0	0	0	+ 2·5600	− 0·6600	+ 1·9000
0					0								0	0
0	0	0	0	0	− 2·0000	− 2·0000	0	0	0	0	0	− 4·5000	+ 0·5230	− 3·9770
				+ 0·08139	0	− 0·06240	+ 0·05887	− 0·03853	− 0·04884	− 0·01357			− 0·23332	+ 5·99357
0	0	0	0	0	0	− 2·0000	0	0	0	− 2·0000	0	+ 12·0200	− 0·1270	+ 11·8930
				+ 0·00235		− 0·00180	+ ·00170	− 0·00111	− 0·00141	− 0·00039			− 0·00672	+ 0·17270
0	0	0	0	0	0	0	0	0	0	0	0	+ 6·9000	+ 1·5870	+ 8·4870
													0	0
0	0	0	0	0	0	0	0	0	0	0	0	− 3·4600	− 0·4670	− 3·9270
													0	0
− 2·0000	0	0	0	0	0	0	0	0	0	0	0	+ 0·7800	− 1·3600	− 0·5800
0													0	0
+ 6·00000	− 2·0000	0	0	0	0	0	0	0	0	0	0	+ 5·0300	− 0·5420	+ 4·4880
0	0													0
	+ 6·0000	− 2·0000	0	0	0	0	0	0	0	0	0	+ 0·9000	− 0·1960	+ 0·7040
	0	0											0	0
		+ 6·0000	− 2·0000	0	0	0	0	0	0	0	0	− 2·8800	+ 0·2370	− 2·6430
		0	0										0	0
			+ 6·0000	− 2·0000	0	0	0	0	0	0	0	+ 4·8400	− 0·8880	+ 3·9520
			0	0									0	0
				+ 6·0000	− 2·0000	− 2·0000	0	0	0	0	0	+ 1·2400	+ 0·6770	+ 1·9170
				− 0·04139	0	+ 0·03173	− 0·02994	+ 0·01959	+ 0·02483	+ 0·00690			+ 0·11864	− 3·04755
					+ 6·0000	0	0	0	0	0	0	+ 1·8500	+ 1·3920	+ 3·2420
					0								0	0
						+ 6·00	− 2·0000	0	0	0	0	− 5·6400	− 0·903	− 6·5430
						− 0·02433	+ 0·02295	− 0·01502	− 0·01904	− 0·00529			− 0·09096	+ 2·33648
							+ 6·0000	− 2·00	0	− 2·00	0	+ 6·6900	− 0·003	+ 6·6870
							− 0·02165	+ 0·01417	+ 0·01796	+ ·00499			+ 0·08582	− 2·20442
								+ 6·0000	0	0	− 2·0000	− 3·1400	− 0·05700	− 3·7100
								− 0·00927	− 0·01175	− 0·00326	0		− 0·05616	+ 1·44252
									+ 6·0000	− 2·0000	− 2·0000	+ 0·0800	+ 0·0960	+ 0·1760
									− 0·01495	− 0·00414	0		− 0·07118	+ 1·82855
										+ 6·0000	0	− 6·6800	+ 0·9450	− 5·7350
										− 0·00115			− 0·01977	+ 0·50793
											+ 6·0000	+ 5·0500	− 1·0190	+ 4·0310
											0		0	0

Reduced Normal Equations

The reduced normal equations is a table showing the equivalent of each unknown in terms of the subsequent unknowns and an absolute term. These are tabulated for convenience as each deduced normal equation can be found on its elimination sheet.

REDUCED NORMAL EQUATIONS

K_1	K_2	K_3	K_5	K_7	K_6	K_4	K_8	K_9	K_{10}	K_{25}	K_{15}	K_{22}	K_{24}
	+·1325111	0	0	−·1994573	0	−·0202809	0	0	0	+·0082772	0	+·0105764	+·0065298
		−·0535715	0	+·0108227	0	+·1985168	+·0022729	0	+·0022729	+·0011786	0	+·0014566	+·0009298
			−·1910377	−·0007009	+·3874539	+·5097690	+·0013462	−·0311216	+·0524191	−·0000763	0	−·0000943	−·0000602
				+·0001941	−·2469734	−·3349568	+·0062058	−·0320670	+·0285950	+·0000211	−·0006060	+·0000261	+·0000167
					−·0005019	+·0122730	+·0000489	+·0000288	−·0000052	−·0023266	−·0000001	+·0088019	+·0338401
						+·2388188	+·0412888	+·0731013	+·0336988	−·0000648	+·0155990	−·0000872	−·0000729
							−·0583751	+·0089496	−·0677627	−·0000095	+·0046349	+·0001663	+·0006008
								+·0243433	+·0573920	+·0000461	+·0044657	−·0000381	−·0002880
									−·0283559	−·0000124	+·0139982	−·0000014	+·0000331
										−·0000243	+·0026296	−·0001660	−·0004810
											−·0000084	+·0028926	+·0006634
												−·0000084	+·0000167
													+·0076383

K_{19}	K_{17}	K_{12}	K_{13}	K_{21}	K_{27}	K_{23}	K_{14}	K_{11}	K_{20}	K_{16}	K_{26}	K_{18}
0	0	+·0007817	0	0	0	−·0099786	0	+·0271307	−·0137953	0	+·0022992	0
−·0037059	0	−·0291403	0	−·0317717	0	+·0057933	0	+·0243689	+·0127110	0	+·0003274	0
+·0002400	0	+·0018872	0	−·0205817	0	−·0003752	+·0153517	−·0015782	−·0008232	+·0016726	−·0000212	+·0041217
+·0075506	+·0196486	−·0005224	0	+·0056975	0	+·0001039	−·0042497	+·0004369	+·0002279	+·0004026	+·0000059	−·0233864
−·0000785	+·0000043	−·0233023	0	−·0006597	−·0300139	−·0544625	−·0000187	−·0110532	+·0061634	−·0000019	+·0598408	−·0000095
−·0023849	+·0189649	+·0016528	−·0584684	−·0178690	+·0000183	−·0002926	+·0239484	−·0013636	−·0007184	−·0395318	−·0000549	+·0111523
−·0474791	−·0511016	−·0136552	−·0161587	+·0380857	−·0005117	+·0023052	+·0269793	−·0121967	−·0100006	−·0091694	+·0010287	+·1137799
+·0258043	+·0388899	+·0065737	−·0176223	+·2317021	+·0002722	−·0011020	+·2589529	+·0076204	+·0060017	+·2501976	−·0005378	+·2027391
−·0096159	+·0024074	−·0007520	−·0512236	+·0060901	−·0000358	+·0001253	+·2958183	−·0011404	−·0008679	−·0291974	+·0000689	−·2417383
+·0379122	+·0552128	+·0108991	−·0118754	+·2413597	+·0003879	−·0018480	+·0154626	+·0083554	+·0070471	−·2770474	−·0007873	−·0615098
−·0001337	−·0000017	−·0000084	+·0000535	−·0011764	+·3353960	−·0006183	−·0000501	+·0095751	−·0038835	+·0000568	+·3325502	−·0000251
−·0031775	+·0014775	−·0003413	+·3199440	+·0003246	−·0000251	+·0000535	+·0133542	−·0009387	−·0006827	+·3255561	+·0000402	+·0059568
−·0002916	−·0001290	+·3304934	+·0000402	−·0015752	−·0035275	+·3234417	−·0000385	+·3451667	+·3313632	+·0000637	+·0108390	+·0001927
−·0005482	−·0004392	−·0119360	−·0000409	−·0013024	+·3231191	+·3089102	+·0000477	+·0034611	+·0031683	+·0000306	+·0359137	+·0007627
	+·0363290	+·0123884	+·0100051	+·0016417	+·0001463	−·0024055	−·0114678	+·0047375	+·3489295	+·0019669	−·0008570	+·2799111
		+·0106204	−·0068263	+·0009920	+·0002353	−·0019980	+·0024545	+·0087997	+·0200575	+·3409497	−·0008076	+·2870118
			+·0011993	+·0331246	+·0082322	+·1384201	−·0012718	−·2781042	+·1171960	+·0031177	+·3672940	−·0124727
				−·0018717	+·0000949	−·0000237	+·3418934	+·0031999	+·0065539	+·1609073	+·0003143	−·0204642
					−·0003586	−·0026258	+·0995715	+·3765434	+·4062160	+·0005096	+·0113170	+·1075329
						+·1622970	−·0001039	+·0087437	−·0048923	+·0001861	+·1229577	−·0005518
							−·0002860	+·1187411	+·1695578	−·0001243	+·4925270	+·0002579
								+·0413402	+·0411854	+·1513637	+·0008771	+·0348146
									+·3467078	+·0131950	−·0669268	+·0377173
										+·0321163	+·1771366	+·2518242
											+·0058277	+·3154988
												+·0400942

Backward Solution (Evaluation of K's)

The Backward Solution is the substitution of each unknown in the reduced normal equation as soon as its value is found for the purpose of evaluating the other unknowns.

K_1	K_2	K_3	K_5	K_7	K_6	K_4	K_8	K_9	K_{10}	K_{25}	K_{15}	K_{22}
+·039547	+·078266	+·059444	+·095204	+·027074	+·103070	+·007670	−·001051	+·128068	+·251761	−·002289	+·252368	+·174216
0	0	−·000624	+·003542	+·000002	−·001689	−·017235	−·030710	+·036617	+·009317	+·000004	−·000904	−·000029
−·000308	−·000044	+·000003	−·000001	−·008004	+·000007	−·000138	+·000072	−·000009	+·000105	−·044481	−·000005	−·001450
0	0	+·000014	+·000003	0	−·000322	−·000075	+·002036	−·000238	−·002255	+·000001	+·002650	+·000001
+·003336	−·003074	+·000199	−·000055	−·001490	+·000174	+·002418	−·001451	+·000210	−·001704	+·000939	+·000165	−·080132
−·003195	−·002870	+·000186	−·000051	+·001302	+·000161	+·001436	−·000897	+·000134	−·000984	−·001128	+·000111	−·040645
− 0	ε	+·001057	−·000293	−·000001	+·001649	+·001858	+·017829	+·020367	+·001065	−·000003	+·000919	−·000003
−·000215	+·000125	−·000008	+·000002	−·001175	−·000006	+·000050	−·000024	+·000003	−·000040	−·000013	+·000001	+·006976
0	0	0	0	−·007208	+·000004	−·000123	+·000065	−·000009	+·000093	+·080547	−·000006	−·000847
0	+·016482	+·010677	−·002956	+·000342	+·009270	−·019758	−·120201	−·003159	−·125211	+·000610	−·000168	+·000817
0	0	0	0	0	+·017865	+·004937	+·005385	+·015652	+·003629	−·000016	−·097761	−·000012
−·000044	+·001622	−·000105	+·000029	+·001297	−·000092	+·000760	−·000366	+·000042	−·000607	0	+·000019	−·018398
0	0	0	+·001462	0	+·001411	−·003801	+·002890	+·000179	+·004107	0	+·000110	−·000010
0	−·000165	+·000007	+·000214	−·000002	−·000067	−·001345	+·000731	−·000272	+·001074	−·000004	−·000090	−·000008
+·001342	+·000191	−·000012	+·000003	+·006955	−·000015	+·000123	−·000059	+·000007	−·000099	+·000136	+·000003	+·001570
+·000445	+·000061	−·000004	+·000001	+·000370	−·000004	+·000007	−·000002	0	−·000007	+·000122	0	
0	0	0	−·000095	0	+·002455	+·000730	+·000703	+·002203	+·000414	−·000001		+·042046
+·000285	+·000041	−·000003	+·000001	−·000080	−·000002	0	+·000002	0	−·000001		+·157412	K_{22}
0	+·000320	+·007373	+·004022	−·000091	+·004740	−·009531	+·008073	−·003988		+·034424	K_{15}	
0	0	−·006094	−·006279	+·000006	+·014314	+·001752	+·004767		+·140657	K_{25}		
0	−·000255	−·000151	−·000696	−·000005	−·004633	+·005550		+·195807	K_{10}			
+·000481	−·004708	−·012089	+·007944	−·000291	−·005664		−·112205	K_9				
0	0	+·055261	−·035225	−·000072		−·023715	K_8					
−·003793	+·000206	−·000013	+·000004		+·142625	K_4						
0	0	−·012757		+·019019	K_6							
0	−·005484		+·066780	K_7								
+·010703		+·102361	K_5									
	+·080774	K_3										
+·048584	K_2											
K_1												

K_{24}	K_{19}	K_{17}	K_{12}	K_{13}	K_{21}	K_{27}	K_{23}	K_{14}	K_{11}	K_{20}	K_{16}	K_{26}	K_{18}
+·126053	+·158247	+·119703	−·000186	−·332495	−·365115	+·252868	+·142493	+·087838	−·037257	−·180250	+·056708	−·127683	−·151474
−·000115	−·042399	−·043475	+·001889	+·003100	−·016288	+·000084	−·000039	−·005274	−·005713	−·038145	−·047790	−·006073	
−·004804	+·000115	+·000108	−·049128	−·000042	−·001514	−·016446	−·065879	−·000117	−·038145	−·023693	−·000779		−·151474
	+·000016	+·002775	+·000025	+·001310	+·000004	+·000002	−·000001	+·001232	+·008952	+·000261		−·133756	K_{18}
−·000766	−·084380	−·004850	−·028341	−·001585	−·098234	+·001183	−·041004	−·009960	+·000107		+·008139	K_{26}	
−·000408	−·000558	−·001036	+·032748	−·000377	−·044339	−·001030	−·013982	−·004868	−·083843	−·241826	K_{16}		
+·000003	−·000790	+·000169	−·000088	+·023540	+·006856	−·000007	−·000020		−·117754	K_{20}			
+·006663	−·000052	−·000043	+·002985	−·000001	−·090058	+·003500		+·068851	K_{11}				
+·077598	+·000035	+·000057	+·001977	+·000023	−·000086		+·021568	K_{14}					
+·000676	−·000852	−·000515	−·017184	+·000971		+·240154	K_{23}						
+·000012	−·003057	+·002086	−·000366		−·518773	K_{27}							
+·000664	−·000690	−·000591		−·305556	K_{21}								
−·000033	+·002702		−·055669	K_{13}									
−·000016		+·074388	K_{12}										
	+·028337	K_{17}											
+·205527	K_{19}												
K_{24}													

Adjusted Directions

The following table shows the observed directions, the corrections and adjusted directions:—

Direction No.	Observed Direction			Correction	Adjusted Direction		
	°	′	″	″	°	′	″
1	133	13	49·344	− ·370	133	13	48·974
2	98	50	06·37	+ ·354	98	50	06·724
2K	52	49	09·675	+ ·016	52	49	09·691
3	277	20	01·224	− ·374	277	20	00·850
4	200	15	13·40	+ ·714	200	15	14·114
4M	141	35	11·44	− ·340	141	35	11·100
5	107	04	14·94	− ·001	107	04	14·939
6	44	53	23·11	+ ·451	44	53	23·561
7	00	00	00	− ·531	359	59	59·469
7E	317	48	13·72	+ ·081	317	48	13·801
8	67	56	57·18	+ ·295	67	56	57·475
9	08	47	48·01	− ·463	08	47	47·547
10	311	53	25·03	+ ·374	311	53	25·404
11	215	53	51·34	− ·103	215	53	51·237
12	154	36	22·22	+ ·167	154	36	22·387
59	111	55	23·41	− ·270	111	55	23·140
13	257	00	44·71	− ·324	257	00	44·386
14	306	37	34·63	+ ·390	306	37	35·020
15	336	07	39·78	+ ·505	336	07	40·285
16	00	00	00	− ·259	359	59	59·741
17	46	53	06·05	+ ·310	46	53	06·360
17La	65	29	25·53	− ·623	65	29	24·907
18	178	19	26·76	− ·061	178	19	26·699
19	250	31	21·36	+ ·208	250	31	21·568
20	00	00	00	− ·135	359	59	59·865
21	40	39	43·80	+ ·173	40	39	43·973
22	87	11	14·26	− ·186	87	11	14·074
23	00	00	00	+ ·138	360	00	00·138
24	294	23	39·43	− ·400	294	23	39·030
25	255	10	02·51	+ ·230	255	10	02·740
25L	215	47	52·87	+ ·033	215	47	52·903
26	309	52	09·90	+ ·733	309	52	10·633
27	00	00	00	− ·685	359	59	59·315
28	31	17	46·14	+ ·051	31	17	46·191
29	119	41	18·09	+ ·210	119	41	18·300
30	190	16	01·52	+ ·459	190	16	01·979
31	244	32	00·90	− ·768	244	32	00·132
32	281	09	01·08	+ ·411	281	09	01·491
33	00	00	00	− ·322	359	59	59·678
34	54	38	58·97	− ·248	54	38	58·722
35	145	19	32·66	+ ·502	145	19	33·162
36	164	54	30·91	− ·343	164	54	30·567
37	52	14	20·89	+ ·067	52	14	20·957
38	00	00	00	− ·465	359	59	59·535
39	305	13	39·17	+ ·535	305	13	39·705
40	270	00	26·06	+ ·034	270	00	26·094
41	226	35	01·73	− ·021	226	35	01·709
41P	190	12	12·78	− ·151	190	12	12·629
42	117	05	51·41	+ ·236	117	05	51·646
43	64	29	52·37	− ·015	64	29	52·355
43H	00	00	00	− ·221	359	59	59·779
44	69	06	15·27	− ·223	69	06	15·047
45	160	07	30·73	− ·035	160	07	30·695
46	230	42	33·65	+ ·206	230	42	33·856
47	329	59	36·33	− ·009	329	59	46·321
48	00	00	00	+ ·061	360	00	00·061
49	238	25	20·99	+ ·263	238	25	21·253
50	292	31	35·86	− ·086	292	31	35·774
51	00	00	00	+ ·147	360	00	00·147

ADJUSTED DIRECTIONS—*Continued.*

Direction No.	Observed Direction			Correction	Adjusted Direction		
	°	′	″	″	°	′	″
52	101	15	54·36	− ·086	101	15	54·274
53	212	51	06·64	− ·238	212	51	06·402
54	00	00	00	− ·182	359	59	59·818
55	23	15	36·05	+ ·441	23	15	36·491
56	71	59	30·91	− ·341	71	59	30·569
56G	111	55	45·03	+ ·082	111	55	45·112
57	108	48	32·73	+ ·012	108	48	32·742
58	149	35	10·95	− ·292	149	35	10·658
58My	194	30	18·26	+ ·280	194	30	18·540

Probable Error of an Adjusted Direction

Of the 68 directions in this net 34 have positive corrections and 34 have negative corrections. The mean of the positive corrections is 0.270″ and the mean of the negative corrections is also 0.270″. The maximum correction −0.768″ to an observed direction occurs for the line North Crosby to Lavant. The correction to each angle is the algebraic difference of the correction to two directions. The maximum correction +1.501″ to any angle is to the angle at Crosby between Lavant and North Elmsley.

The probable error of an adjusted direction

$$= 0.6745 \sqrt{\frac{\Sigma v_2}{\text{No. of conditions}}}$$

$$= 0.6745 \sqrt{\frac{7.46865}{27}} = 0.355''$$

Tabulation of Triangles

In the following table are shown for every triangle in this net, the adjusted spherical angles, the observed angles, the spherical excess and the triangular closure. The plus sign prefixed to the triangular closure indicates that the sum of the observed angles is less than 180°+ E. The negative sign means that the sum of the observed angles is greater than 180° + E.

Of the 21 triangular closures 10 are positive and 11 are negative. The mean of the positive closures is 0.653″, the mean of the negative closures is 0.642″, and the average closure for these 21 triangles is 0.647″. The maximum closing error −1.587″ occurs for the triangle King Mountain–North Mountain–Elmsley.

TABULATION OF TRIANGLES

Station	Symbol	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Lansdowne	− 25 + 24	39 13 36·290	36·92	− 0·630
Crosby	− 27 + 28	31 17 46·876	46·14	+ 0·736
Bastard	− 19 + 20	109 28 38·297	38·64	− 0·343
		E = 1·463	1·70	Δ ar closure = − 0·237
Portland	− 38 + 37	52 14 21·422	20·89	+ 0·532
Lansdowne	− 25Ld + 25	39 22 09·837	09·64	+ 0·197
Crosby	− 28 + 29	88 23 32·109	31·95	+ 0·159
		E = 3·368	2·48	Δ ar closure = + 0·888
Lansdowne	+ 24 + 23	65 36 21·108	20·57	+ 0·538
Elizabethtown	− 7E + 7	42 11 45·668	46·28	− 0·612
Bastard	− 18 + 19	72 11 54·869	54·60	+ 0·269
		E = 1·645	1·45	Δ ar closure = + 0·195
Olden	− 33 + 34	54 38 59·044	58·97	+ 0·074
Portland	− 39 + 38	54 46 19·830	20·83	− 1·000
Crosby	− 29 + 30	70 34 43·679	43·43	+ 0·249
		E = 2·553	3·23	Δ ar closure = − 0·677
Olden	− 32 + 33	78 50 58·187	58·92	− 0·733
Crosby	− 30 + 31	54 15 58·153	59·38	− 1·227
Lavant	− 16 + 17	46 53 06·619	06·05	+ 0·569
		E = 2·959	4·35	Δ ar closure = − 1·391
Kaladar	− 49 + 50	54 06 14·521	14·87	− 0·349
Olden	− 34 + 35	90 40 34·440	33·69	+ 0·750
Portland	− 40 + 39	35 13 13·611	13·11	+ 0·501
		E = 2·572	1·67	Δ ar closure = + 0·902
Kaladar	− 53 + 49	25 14 14·851	14·35	+ 0·501
Lavant	− 17 + 17La	18 36 18·547	19·48	− 0·933
Olden	− 35 + 32	135 49 28·329	28·42	− 0·091
		E = 1·727	2·25	Δ ar closure = − 0·523
Tyendinaga	− 48 + 44	69 06 14·986	15·27	− 0·284
Kaladar	− 50 + 51	67 28 24·373	24·14	+ 0·233
Portland	− 41 + 40	43 25 24·385	24·33	+ 0·055
		E = 3·744	3·74	Δ ar closure = + 0·004
Grimsthorpe	− 55 + 56	48 43 54·078	54·86	− 0·782
Kaladar	− 51 + 52	101 15 54·127	54·36	− 0·233
Tyendinaga	− 47 + 48	30 00 13·740	23·67	+ 0·070
		E = 1·945	2·89	Δ ar closure = − 0·945
Hallowell	− 43 + 42	52 35 59·291	59·04	+ 0·251
Tyendinaga	− 44 + 45	91 01 15·648	15·46	+ 0·188
Portland	− 41P + 41	36 22 49·080	48·95	+ 0·130
		E = 4·019	3·45	Δ ar closure = + 0·569

TABULATION OF TRIANGLES—*Continued*

Station	Symbol	Angle		
		Adjusted	Observed	Correction
		° ′ ″	″	″
Grimsthorpe	− 56 + 56G	39 56 14·543	14·12	+ 0·423
Murray	− 57 + 58	40 46 37·916	38·22	− 0·304
Tyendinaga	− 46 + 47	99 17 12·465	12·68	− 0·215
		E = 4·924	5·02	Δ ar closure = − 0·096
Grimsthorpe	− 54 + 55	35 15 36·673	36·05	+ 0·623
Olden	− 35 + 36	19 34 57·405	58·25	− 0·845
Kaladar	− 52 + 49	137 09 26·979	26·63	+ 0·349
		E = 1·057	0·93	Δ ar closure = − 0·127
Elizabethtown	− 6 + 5	62 10 51·378	51·83	− 0·452
North Mountain	− 4M + 4	58 40 03·014	1·96	+ 1·054
Elmsley	− 9 + 8	59 09 09·928	9·17	+ 0·758
		E = 4·320	2·96	Δ ar closure = + 1·360
Bastard	− 22 + 18	91 08 12·625	12·50	+ 0·125
Elmsley	− 8 + 59	43 58 25·665	26·23	− 0·565
Elizabethtown	− 7 + 6	44 53 24·092	23·11	+ 0·982
		E = 2·382	1·84	Δ ar closure = + 0·542
Lavant	− 14 + 15	29 30 05·265	5·15	+ 0·115
Bastard	− 21 + 22	46 31 30·101	30·46	− 0·359
Elmsley	− 59 + 11	103 58 28·097	27·93	+ 0·169
		E = 3·463	3·54	Δ ar closure = − 0·077
Crosby	− 26 + 27	50 07 48·682	50·10	− 1·418
Bastard	− 20 + 22	87 11 14·209	14·26	− 0·051
Elmsley	− 59 + 12	42 40 59·247	58·81	+ 0·437
		E = 2·138	3·17	Δ ar closure = − 1·032
Lavant	− 14 + 16	53 22 24·721	25·37	− 0·649
Crosby	− 31 + 26	65 20 10·501	9·00	+ 1·501
Elmsley	− 12 + 11	61 17 28·850	29·12	− 0·270
		E = 4·072	3·17	Δ ar closure = + 0·582
Crosby	− 31 + 27	115 27 59·183	59·10	+ 0·083
Lavant	− 15 + 16	23 52 19·456	20·22	− 0·764
Bastard	− 20 + 21	40 39 44·108	43·80	+ 0·308
		E = 2·747	3·12	Δ ar closure = − 0·373
Murray	− 58 + 58My	44 55 07·882	07·31	+ 0·572
Hallowell	− 43H + 43	64 29 52·576	52·37	+ 0·206
Tyendinaga	− 45 + 46	70 32 03·161	02·92	+ 0·241
		E = 3·619	2·60	Δ ar closure = + 1·019
King Mountain	− 2K + 2	46 00 57·033	6·695	+ 0·338
North Mountain	− 4 + 3	77 04 46·736	7·824	− 1·088
Elmsley	− 10 + 9	56 54 22·143	2·980	− 0·837
		E = 5·912	7·499	Δ ar closure = − 1·587
King Mountain	− 2 + 1	34 23 42·250	42·974	− 0·724
Elmsley	− 11 + 10	95 59 34·167	33·690	+ 0·477
Lavant	− 13 + 14	49 36 50·634	49·920	+ 0·714
		E = 7·051	6·584	Δ ar closure = + 0·467

O−C Test (Observed–Computed)

A test of the accuracy of the adjustment is obtained by substituting the v's in the condition equations. The sum of the v's in one condition if accurately determined should equal the absolute term for that condition.

The results of this test are given below. The largest discrepancy occurs for condition No. 1. Here the sum of the v's falls short of the absolute term by 0.000678″.

CONDITION EQUATIONS "O-C"

Condition No.	Absolute Term		
	Observed "O"	Computed "C"	O–C
1	8·60	8·600678	−·000678
2	14·70	14·699746	+·000254
3	10·80	10·800294	−·000294
4	−5·90	− 5·900273	+·000273
5	12·90	12·900052	−·000052
6	7·50	7·499776	+·000224
7	4·30	4·300163	−·000163
8	−0·45	− 0·449993	+·000007
9	0·956	0·956024	−·000024
10	0·660	0·659971	+·000029
11	−0·523	− 0·523025	+·000025
12	0·127	0·127184	−·000184
13	−1·587	− 1·586999	−·000001
14	0·467	0·467000	+·000000
15	1·360	1·359993	+·000007
16	0·542	0·541971	+·000029
17	0·196	0·196029	−·000029
18	−0·237	−0·236960	−·000040
19	0·888	0·887951	+·000049
20	−0·677	−0·677010	+·000010
21	−1·392	−1·391993	−·000007
22	0·903	0·903022	−·000022
23	0·003	0·003003	−·000003
24	0·570	0·569979	+·000021
25	−0·096	−0·095985	−·000015
26	−0·945	−0·945200	+·000200
27	1·019	1·019029	−·000029

Evaluation of Length of sides

In computing the lengths of sides, one-third of the spherical excess was subtracted from each of the spherical angles, and plane triangle formulae were used in computing the lengths.

As a check the distances were computed through different triangles. The largest difference is 3 in the 7th place of logs or 3/4000000, as was to be expected from the agreement shown by the O−C test.

Geographic Co-ordinates

Since the geographic co-ordinates were based on the Canadian Datum no geographical co-ordinates are published, as the final co-ordinates on the North American Datum will be found on page 165.

The method used in computing the geographic positions is given on page 11.

ACCURACY AS SHOWN BY THE SIDE EQUATIONS

Side equations No.	Average Correction that must ensue
1	0·15
2	0·25
3	0·22
4	0·13
5	0·27
6	0·17
7	0·11

Accuracy of the Adjustment

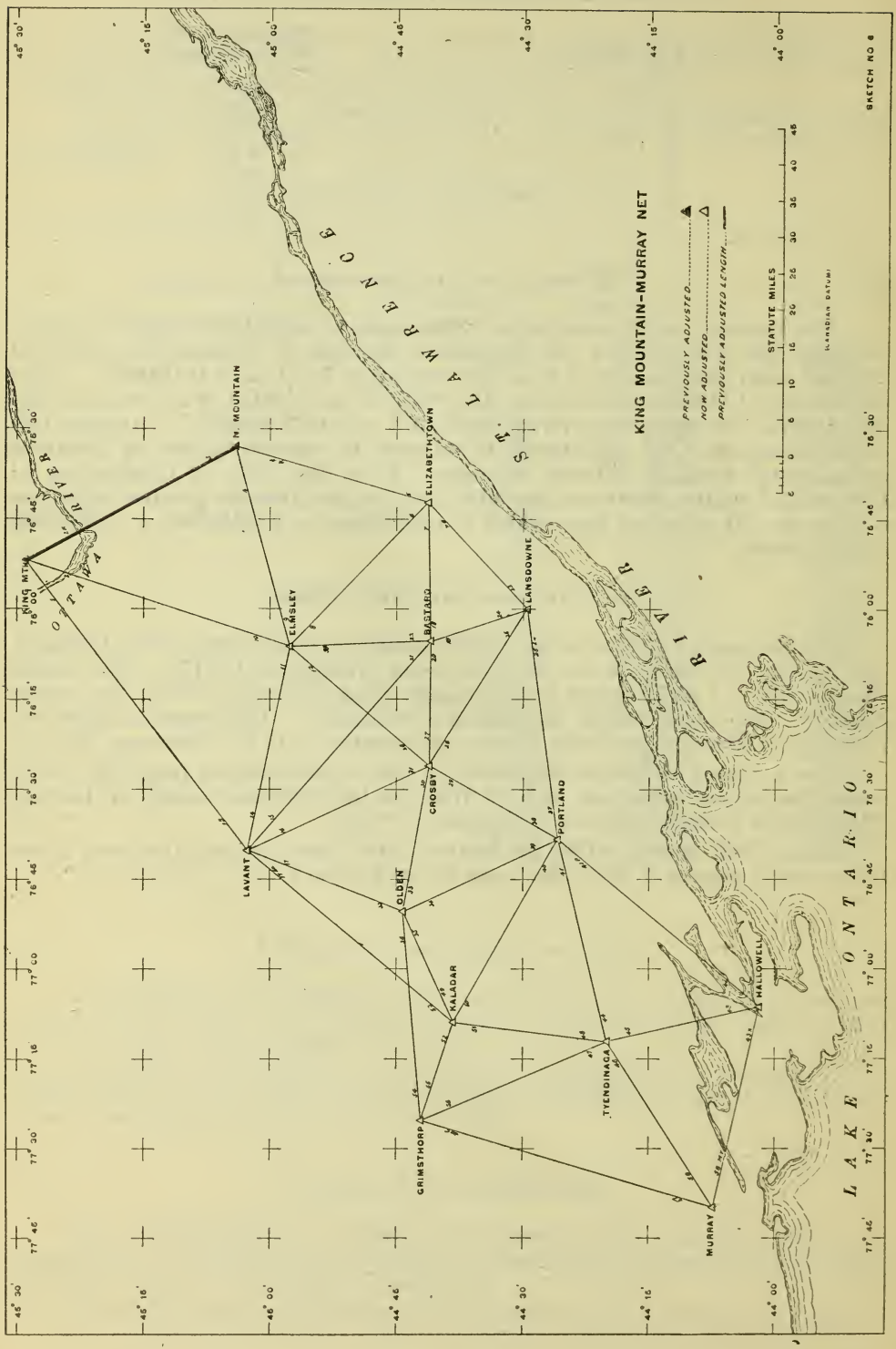
The accuracy maintained in the adjustment is indicated by the O − C test, see page 162 which shows the maximum discrepancy between the observed absolute term and the sum of the *v*'s for condition No. 1 to be 0.000678″. This discrepancy 0.000678″ divided by 12, which is the number of *v*'s for condition No. 1, gives the maximum average error of a *v* to be 0.000057″. Another test of the accuracy of the adjustment is obtained by comparing the log distances as computed through different triangles. From the table of Comparison of Computed Lengths, shown on page 143, it will be seen that the greatest difference is 3 in the 7th place of logs, which is equivalent to 3/4342945 or 3/4000000 approximately.

Accuracy of the Field Work

The accuracy obtained in the field is shown by the closures of the triangles. The average closing error for the twenty-one triangles is 0.647″. The largest closing error −1.587″ occurs in the triangle King Mountain–North Mountain–Elmsley. (See page 160 for tabulation of triangles.) The largest average correction to a direction as shown by the side equation is 0.27″ (See page 152).

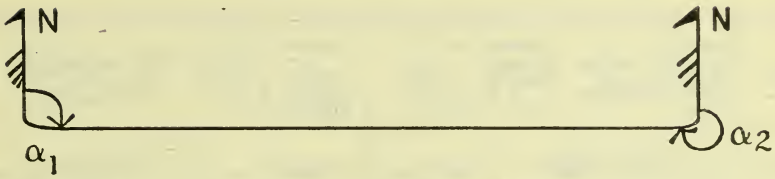
The accuracy is further indicated by the *v*'s tabulated on page 158, which shows the largest correction to be 0.768″ for the direction Crosby to Lavant. The deduced probable error of a direction is 0.355″.

This 0.768″ is well within the limit of three times the probable error where the probable error is 0.355″ (See page 572 of Jordan I.)


KING MOUNTAIN-MURRAY NET
PREVIOUSLY ADJUSTED
NOW ADJUSTED
PREVIOUSLY ADJUSTED LENGTH
STATUTE MILES
(CANADIAN DATUM)
SKETCH NO 8
N. MOUNTAIN
KING MTN.
ELMSLEY
ELIZABETHTOWN
LANSDOWNE
BASTARD
CROSBY
PORTLAND
LAVANT
OLDEN
KALADAR
GRIMSTHORPE
TYENDINAGA
HALLOWELL
MURRAY
ST. LAWRENCE RIVER
RIDEAU CANAL
LAKE ONTARIO

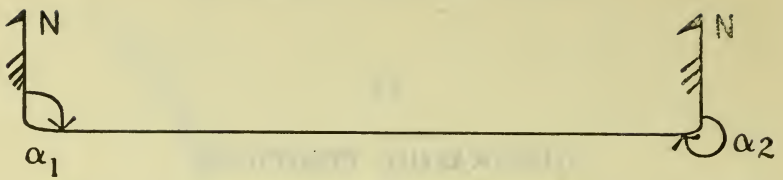
IX

GEOGRAPHIC POSITIONS



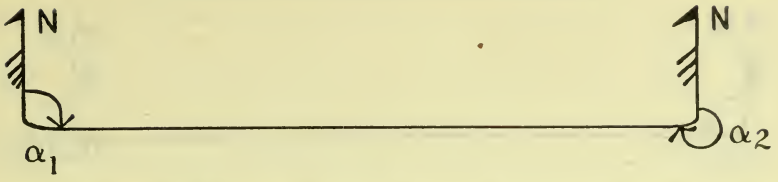
Station 1	Altitude above Mean Sea Level	Latitude and Longitude	Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		44 37 53·626					44 42 20·626	
Methuen		78 00 02·016		79 37 41·04	4·6691716	260 02 07·51	77 25 16·018	Grimsthorpe
							44 15 11·045	
				138 35 09·19	4·7477359	318 54 37·12	77 32 14·005	Oak Hill
							44 23 29·325	
				166 59 10·95	4·4374120	347 02 26·22	77 55 23·466	Asphodel
		44 23 29·325					44 42 20·626	
Asphodel		77 55 23·466		48 37 48·27	4·7244449	228 58 56·23	77 25 16·018	Grimsthorpe
							44 15 11·045	
				116 24 29·27	4·5367713	296 40 40·08	77 32 14·005	Oak Hill
							44 07 22·720	
				145 18 16·09	4·5592805	325 29 03·71	77 39 55·489	Murray
		44 07 22·720					44 42 20·626	
Murray		77 39 55·489		16 38 21·51	4·8300437	196 48 37·01	77 25 16·018	Grimsthorpe
							44 15 11·045	
				35 17 39·08	4·2484621	215 23 00·74	77 32 14·005	Oak Hill
							44 20 06·699	
				57 24 59·21	4·6432700	237 44 25·95	77 12 02·713	Tyendinaga
							44 10 41·527	
				74 10 55·00	4·3549444	254 22 18·15	77 23 34·722	East Base
							44 08 26·084	(Belleville)
				77 43 09·15	3·9649011	257 47 51·49	77 33 10·020	West Base
							44 01 59·672	(Belleville)
				102 20 06·78	4·6623619	282 43 29·38	77 06 19·230	Hallowell
							44 02 48·758	
				113 59 37·68	4·3165465	294 09 29·46	77 25 44·895	Ameliasburg
		44 06 39·816					44 23 29·325	
Haldimand		78 04 30·318		21 13 17·27	4·5242369	201 19 38·86	77 55 23·466	Asphodel
							44 15 11·045	
				69 39 56·39	4·6609817	250 02 25·89	77 32 14·005	Oak Hill
							44 07 22·720	
				87 32 42·40	4·5161576	267 49 49·07	77 39 55·489	Murray
		44 08 26·084					44 15 11·045	
West Base (Belleville)		77 33 10·020		5 40 39·86	4·0990234	185 41 18·92	77 32 14·005	Oak Hill
							44 10 41·527	
				71 50 07·30	4·1287078	251 56 48·08	77 23 34·722	East Base
							44 01 59·672	(Belleville)
				108 15 07·13	4·5771313	288 33 47·84	77 06 19·230	Hallowell
							44 02 48·758	
				136 23 39·13	4·1574019	316 28 48·87	77 25 44·895	Ameliasburg
		44 10 41·527					44 01 59·672	
East Base (Belleville)		77 23 34·722		124 52 06·58	4·4487609	305 04 07·27	77 06 19·230	Hallowell
							44 02 48·758	
				191 14 00·19	4·1724948	11 12 29·58	77 25 44·895	Ameliasburg
		44 02 48·758					44 20 06·699	
Ameliasburg		77 25 44·895		29 36 06·93	4·5667263	209 45 40·03	77 12 02·713	Tyendinaga
							44 01 59·672	
				93 13 41·58	4·4149377	273 27 11·90	77 06 19·230	Hallowell
		44 01 59·672					44 25 59·499	
Hallowell		77 06 19·230		39 49 21·19	4·7634328	220 08 52·73	76 38 19·819	Portland

GEOGRAPHIC POSITIONS—*Continued*



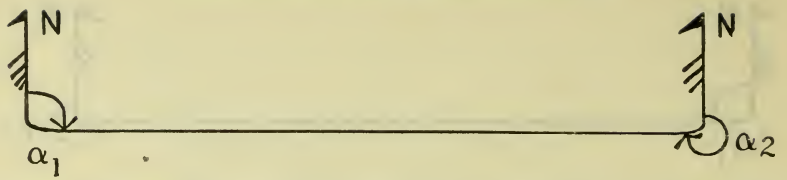
Station 1	Altitude above Mean Sea Level	Latitude and Longitude	Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		44 15 11·045					44 42 20·626	
Oak Hill		77 32 14·005		10 21 56·36	4·7087708	190 26 49·23	77 25 16·018	Grimsthorpe
							44 38 29·314	
				35 32 54·36	4·7253946	215 49 15·96	77 08 52·240	Kaladar
							44 20 06·699	
				71 06 49·26	4·4527405	251 20 55·16	77 12 02·713	Tyendinaga
							44 01 59·672	
				125 06 10·40	4·6265245	305 24 13·22	77 06 19·239	Hallowell
							44 10 41·527	
				125 45 54·51	4·1527726	305 51 56·64	77 23 34·722	East Base
							44 02 48·758	(Belleville)
				159 17 00·67	4·3889600	339 21 31·70	77 25 44·895	Ameliasburg
		44 42 20·626					44 44 29·086	
Grimsthorpe		77 25 16·018		84 52 51·25	4·6654688	265 17 25·87	76 50 20·470	Olden
							44 38 29·314	
				108 08 28·35	4·3582253	288 20 00·02	77 08 52·240	Kaladar
							44 20 06·699	
				156 52 22·53	4·6507611	337 01 38·77	77 12 02·713	Tyendinaga
		44 20 06·699					44 38 29·314	
Tyendinaga		77 12 02·713		7 01 51·91	4·5352123	187 04 05·38	77 08 52·240	Kaladar
							44 25 59·499	
				76 08 06·81	4·6635456	256 31 41·76	76 38 19·819	Portland
							44 01 59·672	
				167 09 22·48	4·5366565	347 13 21·88	77 06 19·230	Hallowell
		44 38 29·314					45 02 44·551	
Kaladar		77 08 52·240		39 55 11·38	4·7687603	220 15 25·47	76 40 10·560	Lavant
							44 44 29·086	
				65 29 26·45	4·4294626	245 42 28·35	76 50 20·470	Olden
							44 25 59·499	
				119 35 41·07	4·6684678	299 57 06·29	76 38 19·819	Portland
		44 44 29·086					45 02 44·551	
Olden		76 50 20·470		21 31 56·31	4·5607199	201 39 06·77	76 40 10·560	Lavant
							44 41 15·556	
				100 22 54·48	4·5146181	280 40 02·31	76 25 59·606	Crosby
							44 25 59·499	
				155 01 53·73	4·5770263	335 10 19·62	76 38 19·819	Portland
		44 25 59·499					44 41 15·556	
Portland		76 38 19·819		29 56 39·26	4·5139614	210 05 18·64	76 25 59·606	Crosby
							44 29 39·773	
				82 11 00·64	4·7114869	262 37 57·01	75 59 52·239	Lansdowne
		45 02 44·551					45 29 21·427	
Lavant		76 40 10·560		51 46 44·22	4·9041063	232 21 05·18	75 51 49·475	King Mtn.
							44 57 48·047	
				101 23 35·01	4·6584475	281 47 35·65	76 06 13·347	Elmsley
							44 41 07·515	
				130 53 40·47	4·7846610	311 18 15·31	76 05 19·930	Bastard
							44 41 15·556	
				154 45 59·96	4·6430286	334 56 00·28	76 25 59·606	Crosby
		44 41 15·556					44 57 48·047	
Crosby		76 25 59·606		40 16 10·61	4·6044601	220 30 06·87	76 06 13·347	Elmsley
							44 41 07·515	
				90 23 59·65	4·4361754	270 38 31·43	76 05 19·930	Bastard
							44 29 39·773	
				121 41 46·44	4·6095990	302 00 06·67	75 59 52·239	Lansdowne
		44 41 07·515					44 41 22·973	
Bastard		76 05 19·930		88 57 57·68	4·4829789	269 14 08·61	75 42 19·279	Elizabethtown
							44 29 39·773	
				161 09 52·80	4·3507457	341 13 42·84	75 59 52·239	Lansdowne
		44 41 22·973					45 04 10·924	
Elizabethtown		75 42 19·279		16 18 23·76	4·6435477	196 25 02·34	75 32 54·421	North Mtn.

GEOGRAPHIC POSITIONS—*Continued*



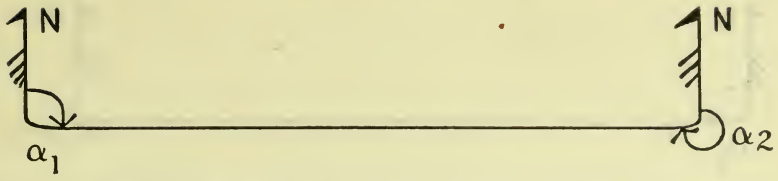
Station 1	Altitude above Mean Sea Level	Latitude and Longitude	]Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		44 57 48·047					45 29 21·427	
Elmsley		76 06 13·347		17 47 09·53	4·7882643	197 57 22·79	75 51 49·475	King Mtn.
							45 04 10·924	
				74 41 31·52	4·6564493	255 05 05·39	75 32 54·421	North Mtn.
							44 41 22·973	
				133 50 41·74	4·6413294	314 07 32·71	75 42 19·279	Elizabethtown
							44 41 07·515	
				177 49 07·53	4·4900630	357 49 45·19	76 05 19·930	Bastard
		44 29 39·773					44 41 22·973	
Lansdowne		75 59 52·239		46 50 03·81	4·5022841	227 02 23·05	75 42 19·279	Elizabethtown
		45 29 21·427					45 37 48·336	
King Mountain		75 51 49·475		65 25 35·36	4·5781779	245 44 30·31	75 25 19·954	Buckingham
							45 30 05·877	
				88 28 00·62	4·8003744	269 02 34·42	75 03 21·742	Plantagenet
							45 26 07·389	
				99 07 15·71	4·5695586	279 27 17·47	75 23 43·488	Navan
							45 13 19·268	
				113 46 58·57	4·8620458	294 23 10·609	75 00 56·661	Roxboro
							45 23 37·076	
				132 18 13·32	4·1980721	312 24 35·61	75 42 52·985	Ottawa
							45 04 10·924	
				151 56 25·38	4·7225283	332 09 51·89	75 32 54·421	North Mtn.
		45 23 37·076					45 37 48·336	
Ottawa		75 42 52·985		40 54 40·43	4·5419556	221 07 11·66	75 25 19·954	Buckingham
							45 26 07·389	
				79 22 07·26	4·4052067	259 35 45·97	75 23 43·488	Navan
		45 30 24·232					45 42 38·835	
Hull		75 50 11·921		1 00 46·64	4·3557001	181 00 59·89	75 49 53·382	Wakefield
							45 37 48·336	
				66 53 08·51	4·5457822	247 10 53·91	75 25 19·954	Buckingham
							45 23 37·076	
				142 45 52·18	4·1980799	322 51 04·98	75 42 52·985	Ottawa
		45 44 24·543					45 56 12·406	
Masham		76 02 17·869		33 32 46·68	4·4190092	213 40 49·60	75 51 04·695	Hincks.
							45 42 38·835	
				101 23 08·21	4·2155463	281 32 01·27	75 49 53·382	Wakefield
							45 30 24·232	
				148 42 12·63	4·4819810	328 50 51·51	75 50 11·921	Hull
		45 57 47·750					46 08 54·034	
Alleyn		76 11 08·370		53 11 43·12	4·5370848	233 27 08·20	75 49 43·371	Blake
							45 56 12·406	
				96 21 29·14	4·4164881	276 35 54·26	75 51 04·695	Hincks
							45 42 38·835	
				135 26 09·22	4·5944082	315 41 23·85	75 49 53·382	Wakefield
							45 44 24·543	
				155 10 16·09	4·4363618	335 16 36·75	76 02 17·869	Masham
		46 08 54·034					45 56 12·406	
Blake		75 49 43·371		184 15 38·83	4·3725530	4 14 40·31	75 51 04·695	Hincks
		45 56 12·406					45 37 48·336	
Hincks		75 51 04·695		135 27 19·73	4·6785326	315 45 46·86	75 25 19·954	Buckingham
							45 42 38·835	
				176·29 09·15	4·4008054	356 30 00·30	75 49 53·382	Wakefield
		45 42 38·835					45 37 48·336	
Wakefield		75 49 53·382		105 33 36·09	4·5202250	285 51 10·08	75 25 19·954	Buckingham
							45 23 37·076	
				165 27 14·35	4·5612160	345 32 14·47	75 42 52·985	Ottawa
		45 37 48·336					45 30 05·877	
Buckingham		75 25 19·954		116 24 31·44	4·5045204	296 40 12·72	75 03 21·742	Plantagenet
							45 26 07·389	
				174 27 55·85	4·3372808	354 29 04·69	75 23 43·488	Navan

GEOGRAPHIC POSITIONS—*Continued*



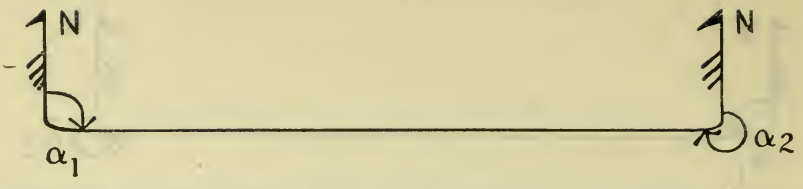
Station 1	Altitude above Mean Sea Level	Latitude and Longitude	Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		45 26 07·389					45 30 05·877	
Navan		75 23 43·488		74 22 27·57	4·4400062	254 36 58·51	75 03 21·742	Plantagenet
							45 17 43·591	
				108 38 20·30	4·6825774	289 03 10·25	74 48 49·702	Maxville
							45 13 19·268	
				128 24 29·01	4·5804259	308·40 41·04	75 00 56·661	Roxboro
							45 04 10·924	
				196 31 21·02	4·6271523	16 24 49·74	75 32 54·421	North Mtn.
		45 30 05·877					45 30 34·132	
Plantagenet		75 03 21·742		88 13 12·10	4·4837329	268 29 52·56	74 39 59·207	Vankleek
							45 17 43·591	
				140 17 58·80	4·4734418	320 28 19·71	74 48 49·702	Maxville
							45 13 19·268	
				174 11 01·63	4·4946515	354 12 44·86	75 00 56·661	Roxboro
		45 13 19·268					45 17 43·591	
Roxboro		75 00 56·661		62 41 18·58	4·2510911	242 49 54·93	74 48 49·702	Maxville
							45 07 33·156	
				126 53 55·68	4·2496728	307 01 36·84	74 50 06·446	Bonville
							45 04 10·924	
				248 11 19·82	4·6550176	67 48 40·30	75 32 54·421	North Mtn.
		45 07 33·156					45 17 43·591	
Bonville		74 50 06·446		5 04 15·44	4·2768962	185 05 09·91	74 48 49·702	Maxville
							45 16 22·149	
				45 05 19·14	4·3647495	225 14 13·06	74 37 33·989	Alexandria
							45 05 33·933	
				94 23 52·43	4·6613861	274 48 33·68	74 15 15·627	Huntingdon
		45 17 43·591					45 30 34·132	
Maxville		74 48 49·702		25 49 17·87	4·4222345	205 55 35·62	74 39 59·207	Vankleek
							45 27 03·091	
				66 38 37·43	4·6424038	247 00 37·24	74 17 55·255	Rigaud
							45 16 22·149	
				99 37 18·63	4·1743386	279 45 18·79	74 37 33·989	Alexandria
							45 05 33·933	
				116 55 46 96	4·6937139	297 19 35 95	74 15 15·627	Huntingdon
		45 16 22·149					45 27 03·091	
Alexandria		74 37 33·989		52 14 27 05	4·5105247	232 28 25·79	74 17 55·255	Rigaud
							45 22 05·910	
				56 24 05·01	4·2836262	236 32 47·95	74 25 18·556	Newton
							45 05 33·933	
				124 16 21·28	4·5491921	304 32 10·66	74 15 15·627	Huntingdon
		45 30 34·132					45 27 03·091	
Vankleek		74 39 59·207		102 38 07·91	4·4695800	282 53 51·90	74 17 55·255	Rigaud
							45 22 05·910	
				129 15 17·11	4·3935661	309 25 44·57	74 25 18·556	Newton
							45 16 22·149	
				173 08 13·78	4·4231032	353 09 57·16	74 37 33·989	Alexandria
		45 22 05·910					45 27 03·091	
Newton		74 25 18·556		46 22 23·84	4·1241116	226 27 39·53	74 17 55·255	Rigaud
							45 17 25·288	
				116 38 26·52	4·2848413	296 47 48 58	74 12 08·224	East Base
							45 13 32·270	
				156 16 07·86	4·2384771	336 19 54·91	74 19 59·108	West Base
							45 05 33·933	
				156 41 49·62	4·5228131	336 48 57·67	74 15 15·627	Huntingdon
		45 17 25·288					45 30 31·591	
East Base (Coteau)		74 12 08·224		62 54 53·53	4·7300814	243 21 02·14	73 35 25·200	Royal
							45 01 05·025	
				133 18 42·32	4·6434262	313 35 58·98	73 47 46·114	Covey Hill

GEOGRAPHIC POSITIONS—*Continued*



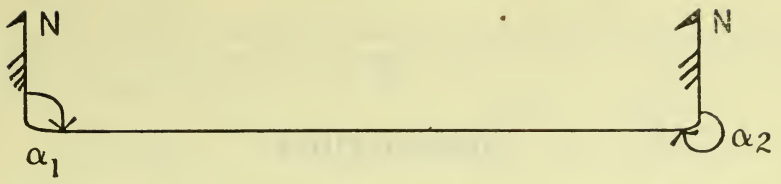
Station 1	Altitude above Mean Sea Level	Latitude and Longitude	Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		45 13 32·270					45 27 03·091	
West Base (Coteau)		74 19 59·108		6 08 11·96	4·4009892	186 09 40·05	74 17 55·255	Rigaud
							45 17 25·288	
				54 56 13·66	4·0981731	235 01 48·12	74 12 08·224	East Base
							45 01 05·025	(Coteau)
				118 26 40·67	4·6824602	298 49 30·41	73 47 46·114	Covey Hill
							45 05 33·933	
				157 13 24·10	4·2044489	337 16 45·11	74 15 15·627	Huntingdon
		45 05 33·933					45 17 25·288	
Huntingdon		74 15 15·627		10 32 02·82	4·3490414	190 34 15·77	74 12 08·224	East Base
							45 30 31·591	(Coteau)
				48 10 04·36	4·8428753	228 38 23·52	73 35 25·200	Royal
							45 01 05·025	
				102 47 23·99	4·5686233	283 06 51·51	73 47 46·114	Covey Hill
		45 27 03·091					45 58 15·430	
Rigaud		74 17 55·255		33 40 21·42	4·8426335	214 01 44·54	73 48 02·766	Kilkenny
							45 30 31·591	
				83 07 05·86	4·7463009	263 37 24·07	73 35 25·200	Royal
							45 01 05·025	
				140 27 15·03	4·7939003	320 48 39·52	73 47 46·114	Covey Hill
							45 17 25·288	
				157 01 12·34	4·2871397	337 05 19·31	74 12 08·224	East Base
							45 05 33·933	(Coteau)
				174 59 14·42	4·6015131	355 01 07·83	74 15 15·627	Huntingdon
		45 58 15·430					45 26 45·626	
Kilkenny		73 48 02·766		128 29 13·70	4·9688063	309 09 13·26	72 52 10·542	Yamaska
							45 30 31·591	
				162 14 27·62	4·7317219	342 23 30·17	73 35 25·200	Royal
		45 30 31·591					46 12 37·374	
Royal		73 35 25·200		21 04 45·21	4·9224820	201 21 32·43	73 12 01·712	Dusable
							45 26 45·626	
				96 47 58·21	4·7542387	277 18 48·14	72 52 10·542	Yamaska
							54 02 47·117	
				127 17 12·81	4·9254948	307 53 28·73	72 44 22·842	St. Armand
							44 46 56·348	
				152 44 52·02	4·9574273	333 07 10·65	73 03 56·928	Bellevue
		45 01 05·025					45 30 31·591	
Covey Hill		73 47 46·114		16 25 33·96	4·7549431	196 34 20·27	73 35 25·200	Royal
							45 26 45·626	
				56 30 06·02	4·9391488	237 09 34·21	72 52 10·542	Yamaska
							45 02 47·117	
				87 27 30·45	4·9207161	268 12 21·320	72 44 22·842	St. Armand
							44 46 56·348	
				114 10 01·422	4·8017852	294 40 57·31	73 03 56·928	Bellevue
		44 46 56·348					45 02 47·117	
Bellevue		73 03 56·928		41 09 05·16	4·5915841	221 22 54·12	72 44 22·842	St. Armand
		45 02 47·117					45 26 45·626	
St. Armand		72 44 22·842		347 06 37·99	4·6586273	167 01 05·85	72 52 10·542	Yamaska
		45 26 45·626					46 12 37·374	
Yamaska		72 52 10·542		343 16 51·56	4·9482328	163 02 37·16	73 12 01·712	Dusable
		46 12 37·374					45 58 15·430	
Dusable		73 12 01·712		240 23 36·88	4·7284571	59 57 39·97	73 48 02·766	Kilkenny
		45 19 40·178					45 29 21·427	
Pakenham		76 21 48·508		65 10 57·65	4·6338848	245 32 18·80	75 51 49·475	King Mountain
							45 20 45·106	
				85 38 29·22	4·4335751	265 53 13·27	76 01 05·561	Carp
							45 09 05·602	
				126 50 53·06	4·5129145	307 05 00·44	76 01 55·118	Ashton

GEOGRAPHIC POSITIONS—*Continued*



Station 1	Altitude above Mean Sea Level	Latitude and Longitude	Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		45 08 56·676					45 19 29·141	
North Gower		75 42 49·624		13 30 52·16	4·3028206	193 33 25·17	75 39 14·130	Bowesville
							45 08 56·307	
				89 54 37·92	4·4069330	270 08 26·20	75 23 21·289	Ormond
							45 04 10·924	
				124 04 36·33	4·1964511	304 11 38·00	75 32 54·421	North Mtn.
							44 53 32·463	
				158 26 18·27	4·4866610	338 32 21·56	75 34 16·039	Groveton
		44 41 22·973					44 53 32·463	
Elizabethtown		75 42 19·279		25 12 26·85	4·3961652	205 18 07·30	75 34 16·039	Groveton
		45 29 21·427					45 19 29·141	
King Mountain		75 51 49·475		137 59 24·55	4·3905790	318 08 22·44	75 39 14·130	Bowesville
		45 04 10·924					45 08 56·307	
North Mountain		75 32 54·421		54 49 50·55	4·1851576	234 56 36·59	75 23 21·289	Ormond
							44 57 33·699	
				120 12 44·26	4·3856009	300 24 01·89	75 16 56·350	Dundela
		45 20 45·106					45 29 21·427	
Carp		76 01 05·561		37 07 35·55	4·3011758	217 14 11·62	75 51 49·475	King Mountain
							45 23 37·076	
				77 18 16·86	4·3867005	257 31 14·39	75 42 52·985	Ottawa
							45 19 29·141	
				94 33 55·31	4·4571514	274 49 28·04	75 39 14·130	Bowesville
		45 09 05·602					45 29 21·427	
Ashton		76 01 55·118		19 18 13·15	4·5997161	199 25 23·80	75 51 49·475	King Mountain
							45 19 29·141	
				56 54 17·15	4·5487589	237 10 23·51	75 39 14·130	Bowesville
							45 08 56·676	
				90 31 05·16	4·4069330	270 44 37·27	75 42 49·624	North Gower
							45 01 14·740	
				149 15 16·19	4·2280386	329 19 55·73	75 55 20·376	Montague
							45 02 44·551	
				257 02 07·54	4·7122252	76 35 01·62	76 40 10·560	Lavant
		45 08 56·307					45 13 19·268	
Ormond		75 23 21·289		74 24 34·88	4·4836915	254 40 28·76	75 00 56·661	Roxboro
							45 01 51·644	
				116 37 55·773	4·4642874	296 51 58·11	75 03 31·915	Osnabruck
		45 19 29·141					45 26 07·389	
Bowesville		75 39 14·130		58 38 31·64	4·3745385	238 49 34·06	75 23 43·488	Navan
							45 08 56·307	
				133 08 02·86	4·4552094	313 19 19·41	75 23 21·289	Ormond
							45 04 10·924	
				163 39 51·66	4·4703056	343 44 21·07	75 32 54·421	North Mtn.
		45 26 07·389					45 08 56·307	
Navan		75 23 43·488		179 07 37·72	4·5028982	359 07 53·50	75 23 21·289	Ormond
		44 53 32·463					45 04 10·924	
Groveton		75 34 16·039		5 10 34·80	4·2964455	185 11 32·49	75 32 54·421	North Mtn.
							45 08 56·307	
				26 37 22·56	4·5040515	206 45 05·71	75 23 21·289	Ormond
							44 57 33·699	
				71 48 40·36	4·3799653	252 00 54·58	75 16 56·350	Dundela
		44 57 33·699					45 08 56·307	
Dundela		75 16 56·350		338 14 58·73	4·3558966	158 10 26·28	75 23 21·289	Ormond
		45 01 51·644					45 13 19·268	
Osnabruck		75 03 31·915		9 03 57·89	4·3323713	189 05 47·91	75 00 56·661	Roxboro
							45 07 33·156	
				59 01 27·71	4·3124136	239 10 58·04	74 50 06·446	Bonville

GEOGRAPHIC POSITIONS—*Concluded*



Station 1	Altitude above Mean Sea Level	Latitude and Longitude	Metres opposite Second of Arc	α_1	Distance in Metres and Log. Distance	α_2	Latitude and Longitude	Station 2
		° ′ ″		° ′ ″		° ′ ″	° ′ ″	
		45 01 14·740					45 19 29·141	
Montague		75 55 20·376		31 53 26·82	4·6002342	212 04 52·11	75 39 14·130	Bowesville
							45 08 56·676	
				48 57 06·26	4·3374003	229 05 57·91	75 42 49·624	North Gower
							45 04 10·924	
				79 24 23·88	4·4764621	259 40 16·36	75 32 54·421	North Mtn.
							44 53 32·463	
				117 07 15·66	4·4937558	297 22 09·01	75 34 16·039	Groveton
							44 41 22·973	
				154 55 41·56	4·6084194	335 04 52·48	75 42 19·279	Elizabethtown
							44 57 48·047	
				246 01 25·07	4·1948550	65 53 43·41	76 06 13·347	Elmsley
		44 07 22·720					44 13 56·090	
Murray		77 39 55·489		33 33 06·933	4·1636005	213 37 19·879	77 33 52·522	Sidney
							43 53 57·044	
				128 36 23·102	4·5991812	308 52 29·806	77 16 44·156	West Point
							44 00 48·821	
				129 04 13·662	4·2847099	309 12 00·609	77 28 44·121	Ameliasburg
							43 53 58·719	(S)
				158 16 15·673	4·4265931	338 21 23·467	77 32 32·493	Scotch Bonnet
							43 59 52·930	
				183 40 28·413	4·1433615	3 40 00·586	77 40 35·503	Presqu'ile
		43 53 58·719					43 53 57·044	
Scotch Bonnet		77 32 32·493		90 02 55·028	4·3256144	270 13 52·607	77 16 44·156	West Point
							43 50 19·861	
				102 07 25·695	4·5026326	282 23 30·615	77 09 20·145	Point Petre
							43 59 52·930	
				315 28 23·066	4·1860188	135 22 47·843	77 40 35·503	Presqu'ile
		44 13 56·090					44 20 06·699	
Sidney		77 33 52·522		68 22 31·144	4·4943609	248 37 45·732	77 12 02·713	Tyendinaga
							44 00 48·821	
				164 12 41·137	4·4022259	344 16 15·850	77 28 44·121	Ameliasburg
							43 53 58·719	(S)
				177 13 59·088	4·5681926	357 14 54·752	77 32 32·493	Scotch Bonnet
		43 53 57·044					43 50 19·861	
West Point		77 16 44·156		124 01 10·430	4·0780096	304 06 18·133	77 09 20·145	Point Petre
		44 01 59·672					43 50 19·861	
Hallowell		77 06 19·230		190 35 58·408	4·3418806	10 33 52·879	77 09 20·145	Point Petre
							43 53 58·719	
				247 12 41·633	4·5807452	66 54 29·412	77 32 32·493	Scotch Bonnet
							44 00 48·821	
				265 57 15·039	4·4775883	85 41 40·402	77 28 44·121	Ameliasburg
							44 13 56·090	(S)
				301 11 32·723	4·6323794	120 52 21·494	77 33 52·522	Sidney
		44 00 48·821					43 53 58·719	
Ameliasburg (S)		77 28 44·121		201 56 10·402	4·1349151	21 53 31·893	77 32 32·493	Scotch Bonnet
							43 59 52·930	
				263 51 23·872	4·2025360	83 43 09·651	77 40 35·503	Presqu'ile

X

DESCRIPTIONS

Methuen.—This station lies on top of a bare rocky hill near the west side of Methuen township, Peterboro county, province of Ontario.

It may be reached from Peterboro by boat to the east end of Stoney lake or by driving from Norwood, on the Canadian Pacific railway, to the east end of Stoney lake. From there a drive of about four miles on the road which follows up the east side of Jack creek brings one to the summit of a ridge, and a little farther on a side road leads in to the east (right) about a mile to an old zinc mine. The station lies up the hill about 100 yards from the mine.

The geodetic point is marked by a $\frac{3}{4}$-inch copper bolt leaded into the rock and stamped with the Geodetic Survey die. It is referenced by two similar bolts placed in the rock, one to the southwest and the other to the north of the point as follows:—

	Distance	Azimuth
No. 1	36·5 feet	247° 26′
No. 2	35·45 feet	357 33

Asphodel.—This station is situated on the top of a bare hill in a cultivated field in Asphodel township, Peterboro county, province of Ontario, on lot 16, concession XII.

The station is marked by an underground and a surface mark consisting of a $\frac{3}{16}$-inch copper wire set in the top of a drain tile which has been filled and surrounded with cement and rock. The tops of the underground and surface marks are one and a half feet and four and a half feet, respectively, below the surface of the ground.

The southeast corner of lot 16 lies 2614·9 feet distant from the point at an azimuth of 105° 53′ 40″, while a post, said to be the township and county corner lies 45 feet from the above lot corner, at a distance from the geodetic station of 2639·1 feet at an azimuth of 106° 44′ 22″.

A concrete reference monument lies on the east side of the road to the west of the station, 1163.70 feet distant at an azimuth of 246° 35′ 05″.

The point may be reached from Havelock or Norwood on the Canadian Pacific railway by a drive of 4 or 5 miles.

The distances from the station mark to the tripod head and lampstand were 72.9 feet and 78·7 feet, respectively.

Haldimand, 1908-10-12.—This station is situated on lot 22, concession VII, of the township of Haldimand, county of Northumberland, and province of Ontario. The property is owned by Dr. T. C. Lapp, of Cobourg, Ont. The post office for the station is Centreton.

The geodetic point is marked by an underground mark consisting of the point of a 3/16-inch copper wire cemented into a 6-inch 2-foot tile, which is set in and filled with cement. Above this is a near-surface mark of the same construction, the upper point of which is 18 inches below the surface of the ground.

The northeast corner of the lot is at an azimuth of 7° 51′ 56″ and distant 1635.76 feet. A concrete monument is at an azimuth of 100° 26′ 34″ distant 73.66 feet from the geodetic point.

The height of the lamp stand and the tripod above the near-surface mark are 67.8 feet and 62.2 feet, respectively.

Murray, 1910-11-12.—This station is situated on lot 16, concession 3, of Murray township, Northumberland county, province of Ontario, about 8 miles

northwest of Trenton. The property is owned by David Murray. The mail address is Hilton, R.R. 1.

The geodetic point is marked in the usual way, the sub-surface mark being 5 feet and the near-surface mark being 2·4 feet below the surface of the ground. The point is referenced thus:—

	Azimuth	Distance
S.E. corner of lot	151° 28′	1682·0 feet
Monument	346° 32′	2310·7 feet

Observations were made from a 70-foot tower, of which the lamp stand and tripod cap are 79·6 feet and 73·8 feet, respectively, above the near-surface mark.

West Base (Belleville), 1912.—This station is situated on the line between lots 5 and 6 in concession II of the township of Sidney, Hastings county, Ontario.

This station, the west end of the Belleville base line, is marked by a copper bolt placed in a large block of concrete, 7 feet below the surface, and is connected as follows:—

A concrete reference monument is distant 632·30 feet, at an azimuth of 160° 45′ 37″.

The distance from the geodetic station to the southwesterly angle of the lots is 2454·56 feet, and the distance from the station to the outside rail of the north track of the Grand Trunk railway main line is 2110·04 feet.

The concrete monument above mentioned is situated alongside the fence on the north side of a forced road, and close to the line on which stands the West Base point.

Observations were made from a 60-foot tower in 1912.

The height of the lamp stand above the tripod head and the sub-surface mark is 5·75 feet and 70·0 feet, respectively.

East Base (Belleville), 1912.—This station is situated at the easterly end of the Belleville base line. It is situated on the property of S. H. Turner, on lot 22 of a subdivision of part of lot 3 in concession II of the township of Thurlow, Hastings county, Ontario. The post office and station is Belleville.

The geodetic point is marked by a millimeter hole in the top of a copper bolt $\frac{3}{4}$-inch in diameter, cemented into the top of a cement slab 3 feet square and 2 feet thick, placed 7 feet below the surface of the ground.

The east edge of a reference monument 1 foot square and 1 foot high is placed on the line between lots 20 and 21, at the centre of which is a copper bolt containing a millimeter hole, distant 74·91 feet from the geodetic point, at an azimuth of 71° 56′ 48″ exactly in the prolongation of the base line. The mark in this reference monument is 42·90 feet north of the north limit of Donald street.

The southeast corner of the township lot is distant 716·45 feet in a direction 62° 40′ 19″ clockwise from a line parallel to Donald street looking east. (The position of the township lot is computed partly from subdivision data.)

Observations were made from a 40-foot tower.

Ameliasburg, 1912 (Primary).—This station is situated on lot 83, concession IV of the township of Ameliasburg, Prince Edward county, Ontario. The owner is Mrs. I. M. Whitney, Ameliasburg.

The station is marked in the usual way by an underground and a surface-mark. Connections are as follows:—

Azimuth to reference monument is 62° 51′ 31″, and the distance is 385·80 feet.

Azimuth to the northeasterly corner of lot 83 is 30° 09′, and the distance is 436·64 feet.

The concrete monument above mentioned is situated along the road fence on the east side of the lot, and 236·61 feet from the northeasterly corner of the lot.

The heights of the lamp stand and tripod head above the near-surface mark are 67·47 feet and 61·6 feet, respectively.

Observations were made from a 60-foot tower.

Oak Hill, 1912.—This station is situated on the highest part of lot 20, concession 7, township of Sidney, county of Hastings, province of Ontario.

The property is owned by B. and A. Hatfield.

The station and post office is Stirling.

The geodetic point is marked by a $\frac{3}{16}$-inch copper wire cemented in the top of a 4-inch by 2-foot tile. The top of the mark is 44 inches below the surface of the ground. A similar mark is placed directly over this, the top being 14 inches below the surface of the ground.

The azimuth to the reference monument is 335° 51′ 54″ and the distance is 3075.8 feet. Distance to west limit of lot is 280 feet.

The reference monument is situated in the northwest angle of the lot.

Height of lamp stand above the surface of the ground is 85·5 feet, and height of the tripod is 80 feet.

Observations were made from this station in 1912.

Grimsthorpe, 1910.—This station is situated on the highest point on mount Maria, supposed to be on lot 23, concession II of Grimsthorpe, Hastings county, Ontario. It is about 10 miles east of the village of Bannockburn on the Central Ontario railway.

The geodetic point is marked in the usual way of marking rock stations, and is referenced by three witness bolts of the same kind which are placed as follows:—

	Azimuth ° ° ″	Distance
Bolt No. 1	226 02 00	54·61 feet
Bolt No. 2	331 35 40	32·92 feet
Bolt No. 3	75 17 00	38·47 feet

Tyendinaga, 1908-10.—This station is situated on the property of John Hunt, lot 23, concession VIII, of Tyendinaga township, Hastings county, Ontario. The post office is Read and the station Marysville on the main line of the Grand Trunk railway.

The geodetic point is marked by the point of a $\frac{3}{16}$-inch copper wire set in concrete in a cleft of a rock about 2 feet below the surface of the ground.

Two reference bolts of $\frac{3}{4}$-inch copper leaded into the rock at the southeast corner of lot 23 are at the following azimuths and distances from the geodetic point:—

	Azimuth ° ′ ″	Distance
No. 1	26 47 08	198·66 feet
S.E. corner of lot	156 43 00	2379·30 feet
No. 2	164 21 00	456·98 feet

The lamp stand is 5.9 and 70.5 feet above the top of the tripod and the geodetic point, respectively.

In 1910 this tower was rebuilt to a height of 21 feet.

Hallowell, 1908-11.—This station is situated on lot 14 in the 1st concession of Hallowell, Prince Edward county, Ontario. The property is owned by John O'Neil, who lives on the property. The post office is Picton.

The geodetic point is marked by the sharpened end of a $\frac{3}{16}$-inch copper wire cemented into a hole drilled in shaley rock 3 feet below the surface of the ground. A large flat rock is placed over this and a 4-inch by 18-inch cement tile filled with concrete is placed above, in the top of which is a $\frac{3}{16}$-inch copper bolt $\frac{3}{4}$ inch of which is protruding. The top of the bolt is 9 inches below the surface of the ground.

The southwest corner of the lot is distant 2240·37 feet at an azimuth of 134° 46′, and a concrete monument near the west limit of the lot is distant 517·62 feet, at an azimuth of 61° 58′ 48″.

The height of the lamp stand above the tripod head and the near-surface mark is 5·5 feet and 87·2 feet, respectively.

Portland, 1908-10.—This station is situated on the property of Frederick Triscott on lot 3, concession VII, of the township of Portland, Frontenac county, Ontario. The post office and railway station is Harrowsmith.

The geodetic point is marked by a cross on a ¾-inch copper bolt leaded into the solid rock 4 inches below the surface of the ground and protruding three-quarters of an inch above the level of the rock.

A reference bolt with a cross upon it is leaded into the rock 10 inches below the surface of the rock, which is indicated by a cross on a rock at the surface above it, and is at azimuth 12° 44′ 00″ at a distance of 387·62 feet. The south-east corner of the lot is at azimuth 126° 27′ 30″ at a distance of 918·06 feet.

Observations were made from a 60-foot tower.

Kaladar, 1908-10.—This station is situated about 3 miles west of a railway station of the same name on the Toronto and Montreal line of the Canadian Pacific railway. It is situated on concession VI, of the township of Kaladar, counties of Lennox and Addington, province of Ontario.

The geodetic point is marked by a cross on the top of a ¾-inch copper bolt leaded into the rock. Two reference bolts leaded into the rock and having arrows cut into the rock pointing to the geodetic point are placed at the following azimuths and distances:—

	Azimuth ° ′ ″	Distance
Bolt No. 1	190 08 30	82·47 feet
Bolt No. 2	60 29 10	94·30 feet

The height of the lamp stand above the tripod head and geodetic point is 5·6 feet and 47·8 feet, respectively.

Olden, 1910.—This station is situated on the west half of lot 14, concession III, of the township of Olden, Frontenac county, Ontario. The property presumably belongs to the Canadian Pacific railway, and is about one-half mile northeasterly from Mountain Grove station.

The geodetic point is marked by a cross in the centre of the top of a flat 16-inch square pillar, which is placed 1283 feet northerly from a forced road, and westerly from the line between the east and west halves of the above lot about 80 feet.

Lavant, 1908-10.—This station is situated on Lavant mountain, on the east half of lot 5, concession X, of Lavant township, Renfrew county, Ontario, about 2 miles east of Lavant station on the Kingston and Pembroke railway. The property is owned by R. B. Robertson.

The geodetic point is marked by a ¾-inch copper bolt leaded into the rock. Two reference bolts, also of copper, are leaded into the rock in the following positions:—

	Azimuth ° ′ ″	Distance
Bolt No. 1	198 17 06	90·75 feet
Bolt No. 2	43 41 50	42·21 feet

The lamp stand is 33·8 and 6·0 feet above the geodetic point and tripod top, respectively.

Crosby, 1908-10.—This station is situated on lot 15, concession VII, of the township of North Crosby, Leeds county, Ontario. The property is owned by Melville Porter, Westport.

The geodetic point is marked by the sharp end of a $\frac{3}{16}$-inch copper wire set in concrete in a crevice of the rock 24 inches below the surface of the ground. The northwesterly corner of the lot is distant 981·882 feet at an azimuth of

284° 57′ 25″. A concrete reference monument is distant 797·214 feet at an azimuth of 333° 37′ 29″.

The heights of the lamp stand and top of the tripod head above the geodetic point are 104·3 feet and 98·2 feet, respectively.

Bastard, 1910.—This station is placed on part of lot 10, concession VI of the township of Bastard, Leeds county, Ontario. The property is owned by Wm. Wier, Chantry, Ont.

The geodetic point is marked in the usual way, the near-surface mark being 1½ feet below the surface of the ground.

Connection was made to a reference monument and to the southwesterly corner of above lot, as follows:—

	Azimuth ° ′ ″	Distance
Monument	164 57 40	484·5 feet
S.W. corner of lot	165 06 26	491·0 feet

The tripod head and lamp stand are 83·0 feet and 88·8 feet, respectively, above the near-surface mark.

Lansdowne, 1909-10.—This station is situated on Blue mountain on lot 24, concession VI, of the township of Lansdowne, Leeds county, Ontario. The land is owned by Harvey Osten. The post office for the station is Warburton.

The geodetic point is a mark on a ¾-inch copper bolt leaded into the rock. Over it is a concrete pier 4 feet high, with another marked bolt at its surface.

The following marks are located with reference to the geodetic point:—

	Azimuth ° ′ ″	Distance
¾-inch copper bolt	181 02 47	116·85 feet
¾-inch copper bolt	23 42 21	158·93 feet
Head of screw in pine tree	21 46 24	112·79 feet
N.E. corner of lot	36 44 45	331·06 feet

Lansdowne station on the Grand Trunk railway lies about 7 miles to the south.

Elizabethtown, 1908-10.—This station is situated on the property of John Vout, on what was originally called the Commons between the townships of Elizabethtown and Augusta, and lies in concession V, of the township of Elizabethtown, Leeds county, Ontario. The post office is Algonquin.

Brockville, on the main line of the Grand Trunk railway, lies about 8 miles to the south.

The geodetic point is marked by the sharpened end of a $\frac{3}{16}$-inch copper wire concreted into the top of a 24-inch tile. Above this, and separated by 6 inches of sand, is a near-surface mark of a similar construction, 12 inches below the surface of the ground.

The northwest corner of lot 37, concession V of Augusta is distant 900.90 feet at an azimuth of 359° 36′ 45″ and a concrete reference monument near the west limit of the lot is distant 399·30 feet at an azimuth of 280° 18′ 22″.

The heights of the lamp stand and tripod top above the near surface mark are 89·2 feet and 83·0 feet, respectively.

North Elmsley, 1908.—This station is situated on lot 1, concession X, of the township of North Elmsley, Lanark county, Ontario, and is the property of Joseph O. Code, Glen View.

The geodetic point is marked in the usual way by an underground and a surface mark, the near-surface mark being 1·5 feet below the surface of the ground.

The azimuths and distances to the lot corner and reference monument are as follows:—

	Azimuth ° ′ ″	Distance
SW. corner of lot	140 58 45	2768 feet
Concrete mounment near the line between lots 1 and 2 and concession X	242 49 09	91·67 feet

Observations were made from a tower of which the cap of the tripod is 96·8 feet, the lower lamp stand 102·6 feet, and the upper lamp stand 112·2 feet, respectively, above the geodetic point.

King Mountain, 1907-09-11.—This station is situated on the highest part of a mountain of the same name which is one of the highest parts of the range of hills about 9 miles north of the city of Ottawa. It is located in the township of Hull, county of Ottawa, province of Quebec.

This is an eccentric station and lies about 211 feet south on the bare front of the hill. The main station occupies the highest point on the hill.

The main station is marked by a copper bolt set in the rock, around which are deep arrows cut in the rock pointing to the centre as follows:—

South of the point and distant 6·80 feet
Northwest of the point and distant 4·42 feet
Northeast of the point and distnat 4·82 feet

It is also referenced by three copper bolts set in the rock as follows:—

	Azimuth ° ′ ″	Distance
Bolt No. 1	191 40 30	41·6 feet
Bolt No. 2	191 42 00	144·66 feet
Bolt No. 3	97 57 30	194·67 feet

The eccentric station lies distant from the geodetic station 210.89 feet at an azimuth of 110° 33′ 17″. It is marked by a ¾-inch copper bolt set in the rock and is referenced by three similar bolts as follows:—

Approximate azimuth	Distance
150°	7·68 feet
240	1·60 feet
315	8·85 feet

The station may be reached from Chelsea on the Canadian Pacific railway by a drive of 2 miles to Kingsmere and a walk of 1½ miles up the hill from the west end of Kingsmere lake.

North Mountain, 1907-10.—This station is situated on the east half of lot 4, concession X, of the township of North Mountain, Dundas county, Ontario. The property is owned by Laverty Caughey and is about 7 miles northeast of Kemptville on the Ottawa–Prescott branch of the Canadian Pacific railway The post office is North Mountain.

The geodetic position is marked by a subsurface and a near-surface mark, each of which consists of the point of a spike cemented into a 4-inch by 24-inch tile filled with concrete. A 6-inch layer of sand is placed between the two marks, and the near space about the tile is filled with layers of concrete and stones. The upper mark is about 14 feet below the surface of the ground.

A concrete reference monument placed near the east limit of the west half of the lot is distant 523·79 feet at an azimuth of 201° 47′ 15″.

The southwest corner of the east half of lot 4, concession X is distant 1746 feet at an azimuth of 162° 49′ 31″.

Observations were made from a 70-foot tower.

Roxboro, 1907-08-09.—This station is situated on the property of Daniel Blair, farmer, who lives about 100 yards west of the tower on the west half of lot 32, concession VI of the township of Roxboro, Stormont county, Ontario. The post office and station is Moose Creek, on the Grand Trunk railway.

The geodetic position is indicated by a subsurface and a near-surface mark of the usual kind. Each mark has a pointed nail cemented into a 4-inch by 24-inch tile; the tiles are placed vertically and are separated by 6 inches of sand, the upper one being 10 inches below the surface of the ground.

A reference monument placed on the easterly side of the west half of the above lot is 2312 feet southerly from the north limit, and at a distance of 121·38 feet from the geodetic point at an azimuth of 42° 44′. The intersection of the

north limit of a road allowance (probably forced) and the line between the east and west halves of the lot is distant 754·4 feet at an azimuth of 143° 47′ 10″.

The height of the lamp stand above the top of the tripod and the near-surface mark is 6·1 feet and 77·0 feet.

Navan, 1907-08-09-11.—This station is situated on lot 10, concession VI, of the township of Cumberland, Russell county, Ontario. The property is owned by the Canada Permanent Loan Company, and the post office is Navan on the Canadian Pacific railway.

The geodetic point is marked by a crow's foot on a $\frac{3}{8}$-inch copper bolt, 6 inches long, which is driven into the rock to a depth of $5\frac{1}{2}$ inches. The rock is 1 foot below the surface.

Connection is made to a concrete witness monument situated at an azimuth of 245° 18′ 42″ and distant from the geodetic point 316·76 feet, and also to the southwesterly angle of the lot which lies at an azimuth of 198° 36′ 25″ and distant from the geodetic point 614·2 feet.

Observations were made at this station from an 80-foot tower in 1908, 1909, and 1911.

Buckingham, 1909-11.—This station is on Kermans mountain on lot 10, concession VIII, of the township of Buckingham, Ottawa county, Quebec.

The geodetic point is marked on a $\frac{3}{4}$-inch copper bolt 5 inches long leaded into the rock. Reference bolts of the same size, leaded flush with the rock, are placed at an azimuth of 177° 45′ and distant 29·16 feet and at an azimuth of 131° 53′ 26″ and distant 85·76 feet, respectively.

Observations were made from a low tripod in 1911.

Plantagenet, 1907-09.—This station is situated on lot 16, concession VI, Plantagenet township, Prescott county, Ontario. The property is owned by Ben Anderson, and the post office is Plantagenet.

The geodetic point is marked by the point of a nail cemented into a tile 3 feet below the surface of the ground. A similar mark is placed 9 inches below the surface.

Connection is made to a concrete witness monument on the west side of the lot in the northwesterly corner of a field at an azimuth of 283° 50′ and distant 133·92 feet from the geodetic point.

The distance measured along the lot line from the monument to the northerly limit of the lot is 589 feet.

Maxville, 1907-10.—This station is situated on lot 33, concession VI of the township of Kenyon, Glengarry county, Ont., 2,800 feet southwesterly from the right way of the Grand Trunk railway where it crosses the road allowance between concessions V and VI of said township, measured along the said road allowance. The post office for the station is Maxville.

The geodetic point is marked by the point of a 6-inch spike which is placed head down in a concrete slab, 3·2 feet below the surface. An upper mark 10 inches below the surface similar to the above, but in a tile, is also placed.

Connection is made to a concrete witness monument distant 320·21 feet at an azimuth of 223° 00′ 15″.

Observations were made from a 95-foot tower.

Bonville, 1908.—This station is situated on the east half of lot 15, concession VIII of the township of Cornwall, Stormont county, Ontario. The property is owned by Arthur Beaudette, whose post office address is Bonville.

The geodetic point is marked by the point of a 6-inch spike placed head down in cement in a 4-inch by 2-foot tile set in cement. Immediately above this subsurface mark a flat stone is placed, and above this, a near-surface mark similar in construction to the subsurface mark is placed 18 inches below the surface of the ground.

The southwesterly corner of the east half of lot 15 is distant 1080·4 feet at an azimuth of 178° 20′ 15″. A reference monument is placed close to the same lot corner at a distance of 1070·8 feet in the same direction.

Observations were made from a 70-foot tower in 1908.

Alexandria, 1907-08.—This station is situated on lot 4, concession 18 of the township of Kenyon, Glengary county, Ontario. The property is owned by H. Duggan, and the post office is Alexandria.

The geodetic point is marked by the point of a nail placed in a heavy cement base, 3 feet below the surface. A surface mark of the usual kind is placed in a tile.

Connection is made to a witness monument placed at an azimuth of 209° 55′ 44″ and distant from the geodetic station 169·58 feet. The distance to the northerly limit of the lot is 3,800 feet.

Observations were made from an 80-foot tower.

Vankleek, 1907-08-10.—This station is situated on the west side of lot 10, concession VI of the township of West Hawkesbury, Prescott county, Ontario. The property is owned by Charles Carkner, Vankleek Hill.

Connection is made to a concrete witness monument placed at an azimuth of 298° 55′ 09″ and distant 64·63 feet.

The geodetic point is marked by the point of a wire nail in the usual way. The subsurface mark is 42 inches and the near-surface mark is 7 inches below the surface.

Observations were made from an 80-foot tower.

Newton, 1908.—This station is on lot 173, range 4, township of Newton, Vaudreuil county, Quebec.

The land on which the station is placed is owned by Geremie Richor.

The station is marked by copper pins, the lower mark in a concrete block 2 feet square, below the surface, and the upper mark in the centre of a concrete filled artificial clay sewer tile, on end 15 inches below the surface.

The point is referenced as follows:—

	Azimuth	Distance
Northeast angle lot 173	24° 51′ 14″	2942 ft.

A tripod, 75·2 feet high, and a scaffold, 80·8 feet above the lower mark, were erected for observing purposes.

The geodetic station is about five hundred feet west of the main road from St. Justine station on the Grand Trunk railway to the village of St. Justine, and about half a mile from the railway.

Huntingdon.—This station is on lot 77, range 4, township of Godmanchester, Huntingdon county, Quebec. The land is owned by Angus Stark, who lives a short distance east of the station.

The station is marked by underground and surface marks consisting of small spikes in the centres of concrete-filled vitrified clay sewer tiles placed on end; the lower one 4·6 feet and the upper one 0·8 foot below the surface of the ground.

References are as follows:—

Reference	Azimuth	Distance
Concrete monument	248° 52′ 10″	131·51 ft.
Northwest angle of lot 77	318 16 55	3166·80 "

Azimuth is counted from north through east.

A tripod 71·5 feet above the surface mark and a scaffold for the observer having a lamp table 5·8 feet higher were erected over the station.

Huntingdon may be reached from the railway station of that name on the Grand Trunk and St. Lawrence and Adirondack railways, by a drive of about five and one-half miles. D.J.F.

East Base (Coteau).—This station is situated on the right of way of the Grand Trunk railway main line Montreal–Toronto, about one mile east of Coteau Junction. The station is on the south side of the railway track about 40 feet from the track on first curve east of Coteau Junction. There is a 70-foot tower. D.J.F.

West Base (Coteau).—This station is situated on the right of way of the Grand Trunk railway main line Montreal–Toronto about one-quarter mile west of River Beaudette station on a gravel knoll on north side of track, about 30 feet from track.

Rigaud, 1908.—This station is situated on the highest point on Rigaud mountain, on lot 152, concession of St. George, parish of Ste. Madeleine of Rigaud, Seignory of Rigaud, Vaudreuil county, Quebec, and owned by Noe D'Amour.

The station is marked by a brass bolt leaded in the rock 3·5 feet below the surface of the ground. Above the geodetic point a rough stone cairn is built to mark the spot.

The heights of the tripod and lamp stand were 44·28 feet and 50 feet, respectively, above the gedoetic point.

The station is referenced as follows:—

	Azimuth	Distance
Southeast angle of lot 152	265° 42′	235·67 ft.

Azimuth is measured from north around through east, and is given to the nearest minute of arc.

The nearest railway station is Rigaud on the Canadian Pacific railway, from which the geodetic station is reached by driving southerly three miles to the St. George road, thence westerly three-quarters of a mile, the point being then on the right, close to the road.

Kilkenny, 1909.—This station is situated on lot 2, concession V, Montcalm county, Quebec.

The geodetic point is marked in the usual rock-station method, and is 2 feet below the surface of the ground.

The point is referenced by three $\frac{3}{4}$-inch reference bolts leaded into outcropping rocks, which are at the following azimuths and distances from the station:—

	Azimuth	Distance
Reference bolt	209° 25′ 48″	40·76 ft.
Reference bolt	12 53 58	38·21 "
Reference bolt	150 51 28	41·31 "
Lot corner	151 58 29	1172·17 "

Observations were made from a 40-foot tower. The heights of the lamp stand and tripod head above the geodetic point are 51·2 feet and 45·1 feet, respectively. The height of the instrument above the tripod head is 1·53 feet and the height of the centre of lamp above the lamp stand is 0·6 feet.

Covey Hill, D. J. F., 1908, 1910, H. F. J. L., 1917.—This station is located on a hill of that name in the province of Quebec, county of Huntingdon, township of Havelock, on lots 34C and 35C of range I on the property of John Waddell (P.O. Franklin Centre, Que.).

The station is marked by an iron bolt leaded into the rock, and is referenced by two copper bolts leaded into the rock along the south fence of the main road, about 350 feet north of the station.

These reference bolts and the northeast corner of lot 34C, range I, are located as follows with reference to the station:—

	Azimuth	Distance
Bolt No. 1	337° 27′ 56″	338·5 ft.
Bolt No. 2	28 14 12	357·93 "
Northeast corner of lot 34C	69 28 14	922·9 "

Bolt No. 1 was not found in 1917, being covered with rock thrown in against the fence.

The distance, measured along the road fence from the above-mentioned northeast corner of the the lot to bolt No. 2 is 694.98 feet, and from Bolt No. 2 to Bolt No. 1 is 298·45 feet.

St. Armand.—This station is on the top of a mountain called " The Pinnacle " in the township of St. Armand, county of Missisquoi, province of Que-

bec. The station is most easily reached from the town of Richford on the Newport and Boston branch of the Canadian Pacific railway by a drive of four miles to the farm of F. S. Clark, and thence by way of a path leading from the back of his farm to the top of the mountain.

The top of the mountain is almost bare rock, with scattered small scrub. An unobstructed view can be had in all directions. To the north of the summit is a triangulation station used by the Militia Department marked by a copper bolt with a cross on it. The summit of the hill is a flat rock which was selected as the best location for the station.

The point is marked by a copper bolt leaded in the rock—an equilateral triangle is cut around it; the bolt is stamped with the geodetic die; it is referenced by three arrows cut in the rock, with copper bolts at their points, situated as follows:—

	Azimuth	Distance
	86° 34′	24·3 ft.
	170 30	49·6 "
	311 08	43·5 "
Station of Militia Dept.		
	345° 50′	133·23 ft.

Three concrete foot blocks for the tripod of the large observing instrument were built, also a lamp stand for the lightman; the directions of the principal points were marked on the top of the stand.

Yamaska, 1909-10.—This station is situated on Yamaska mountain in the parish of St. Paul D'Abbotsford, Rouville county, Quebec, and is one mile northeast of the village of Abbotsford.

The point is marked in the usual method for rock stations, with reference bolts as follows:—

	Azimuths	Distance
Reference bolt	50° 32′ 48″	4·21 ft.
Reference bolt	107 05 00	21·13 "
Militia Survey bolt	263 10 46	46·09 "
Reference bolt	260 24 11	44·24 "

Dusable, 1909-10.—This station is situated on the property of Charles Faford, on lot 88, range IV, seigniory of Dusable, county of Berthier, province of Quebec. It is on bare rock on the summit of a low rocky knoll, two sides of which are wooded with pine, maple, and birch.

The station is reached from St. Barthelemy on the Canadian Northern Quebec railway; thence drive one-half mile northwest to the fourth or Belleton range, then one-half mile south-southwest along Belleton range several hundred yards past a cross road to the farm of Louis Fadnois. From here the geodetic station lies one-quarter of a mile southeast, and Faford's bush road may be followed to it.

The geodetic point is marked by a copper bolt marked in the usual manner, fox-wedged and leaded in the rock and surrounded by an equilateral triangle cut in the rock, referenced as follows:—

	Azimuth	Distance
Copper bolt	58° 54′	64·5 ft.
"	161 58	70·2 "
"	275 32	44·8 "

Lines are cut to Yamaska and Mount Royal, the other lines being clear.

Hull, 1913.—This station is situated on the timbered top of the same range of mountains as King Mountain station, is within a few feet of the edge of the Chelsea mountain, and is near the line between lots 17 and 18 in range IX of the township of Hull in the county of Ottawa and close to the north easterly angle of the south half of lot 18.

The station is marked by a copper bolt, three-quarters of an inch in diameter, in solid rock, with reference bolts of the same size as follows:—

	Azimuth	Distance
Copper bolt	269° 09′ 39″	68·48 ft.
"	325 09 45	29·97 "

Chelsea is the nearest station on the Canadian Pacific railway, thence by main road via Old Chelsea to a trail which starts up the mountain nearly opposite Mr. O'Neill's house on the west side of the most southerly of two large elm trees at the foot of the mountain near a very large boulder. The trail from this point to the top of the hill is blazed.

Lot 18 is owned by Ambrose Richards, Simmons P.O., Que.

Wakefield, J. H. Moorhouse, 1913.—The station is on a high, rough, rocky hill, the most prominent in that locality, on lot 15 range VII of the township of Wakefield in the county of Ottawa. The station is placed on the summit of a sharply defined elevation of solid rock and is marked by a copper bolt three-quarters of an inch in diameter, referenced as follows by similar bolts:—

	Azimuth	Distance
Copper bolt	294° 31′ 35″	46·99 ft.
"	204 15 15	80·39 "

Alcove station on the Canadian Pacific railway is the nearest railway station; thence 6 miles by road to McLaren's lumber camps—now abandoned—thence by blazed trail to the top of the hill about one hour's walk in a northeasterly direction from the lumber camp. The position of the lumber camps mentioned is known to many residents of Alcove.

Masham, J. H. Moorhouse, 1913.—This station is on the top of a high hill northeast of Long lake, on lot 27, range X, Masham township, in the county of Ottawa, and is marked by a copper bolt, three-quarters of an inch in diameter, in solid rock. Reference bolts of the same size have been placed as follows:—

	Azimuth	Distance
Copper bolt	187° 25′ 25″	64·12 ft.
"	338 21 22	24·00 "

The point is near the southerly escarpment of the hill near small pine trees and may be reached from North Wakefield station—now called Alcove—on the Canadian Pacific railway, by a drive of about 8 miles to the foot of the hill, thence by a blazed trail up the hill and around through the bush on the north side of the lake, to the highest point northwest of the lake. Mr. T. A. Cooper of North Wakefield or Mr. S. Brooks of Joynt are familiar with the location of this station.

Hincks, J. H. M., 1913.—This station is situated on lot 35, range IX, of the township of Hincks, Ottawa county, Quebec. It is on the highest mountain in the township. The top of the mountain on which the point is situated is of small area and stands above all surrounding timber.

The mark is a copper bolt, $\frac{3}{4}$-inch in diameter, in solid rock, surrounded by a triangle cut in the rock with 8-inch sides. Similar reference bolts have been placed as follows:—

	Azimuth	Distance
Reference bolt	217° 42′ 15″	27·36 ft.
Hole in rock without bolt	305 46 54	42·06 "
Reference bolt	57 41 25	43·53 "

The nearest railway station is Kazubazua on the Canadian Pacific railway; thence follow the road to Ryanville and Big Whitefish lake to a small lake on the north side of the road, about three miles east of William Newton's residence. Small vacant buildings stand near the east end of the lake. A blazed trail starts at the south side of the road opposite that end of the lake, and ends within 50 feet of the top of the mountain.

Alleyn, J. H. Moorhouse, 1913.—This station is situated in hardwood forest on the highest part of the hill southeast from the residence of Samuel Morehead, on lot 10, range V, in the township of Alleyn, county of Pontiac.

The station is marked by a copper bolt, three-quarters of an inch in diameter, in solid rock, with similar reference bolt as follows:—

	Azimuth	Distance
Reference bolt	204° 47′ 01″	35·40 ft.

The station is reached from Kazubazua on the Canadian Pacific railway, via Danford lake post office to Mr. Morehead's residence about 5 miles from Danford lake.

Blake, J. H. M. 1913.—This station is on the highest point on a prominent round-topped mountain on the west side of Thirty-one Mile lake, about six miles from the south end of the lake, in the township of Blake, in the county of Ottawa. From the north around to the west, clockwise, the horizon is unobstructed.

The geodetic point is marked by a bronze bolt with circular cap on which a small triangle is cut, with the letters "G.S.C." outside of the triangle. The Geodetic Survey stamp, has been placed in the centre of the triangle. Copper reference bolts, three-quarters of an inch in diameter, have been placed in the solid rock as follows:—

	Azimuth	Distance
Reference bolt	334° 15′ 59″	56·97 ft.
"	47 00 35	34·58 "
"	156 50 10	28·98 "

The mountain can be reached from Gracefield on the Canadian Pacific railway, and by road from that place to Point Comfort and from Point Comfort to the foot of the mountain by boat.

Ottawa.—This station is in the township of Nepean, county of Carleton, province of Ontario.

It is situated on the concrete roof of the staircase projection just north of the equatorial dome of the Dominion Observatory.

It is marked by a copper bolt cemented into the roof.

Bellevue (U.S.C. and G.S. Primary Station), R. C. Cutts, 1881.—This station is on the summit of a hill about 2 miles southeast of the village of St. Albans, Vermont, on the site of an old observatory on the highest part of the hill; marked by the usual copper bolt and arrow heads.

A. T. Mosman, 1897.

Recovered copper bolt marking station of 1881. It is on the highest rock on the summit of Bellevue hill. The "usual arrow heads" spoken of in the above 1881 description could not be found.

D. J. Fraser, 1910.

The above United States point was found and used by observer and lightkeeper.

Mount Royal, R. D. Cutts, 1881.—This station stands on the highest ground in Mount Royal Park, Montreal. Its position is close to the Meteorological Observatory of McGill College, consisting principally of a large post, supported by braces and of sufficient height to overlook the surrounding trees. To this post, the meteorological instruments and a small platform for the observer are attached.

The United States Coast and Geodetic station was established by extending the platform, southwardly, with additional supports, so as to afford a seat to the heliotroper, and a firm rest for the heliotrope. After the heliotrope was in position, the corresponding point on the ground was carefully determined and a bolt sunk in the rock which was reached $1\frac{1}{4}$ feet below the surface of the ground. The bolt projects six inches above the rock.

The station point is $5\frac{3}{4}$ feet south of the centre of the post, and one foot from the fence (appropriately marked) situated farther to the southward and in line with the bolt and the centre of the post.

A. T. Mosman, 1897; bolt recovered. In Mount Royal park, $1\frac{1}{2}$ miles north of Montreal.

Pakenham, 1908.—This station is situated on the property of Allan Carswell, on lot 17, concession VIII, of the township of Pakenham, Renfrew county, Ontario. The post office and station is Pakenham on the Canadian Pacific railway, about 5 miles east.

The geodetic point is marked by the point of a $\frac{3}{16}$-inch copper wire set in concrete in a hole drilled in the solid rock, $1\frac{3}{4}$ feet below the surface of the ground.

A concrete reference monument is distant 215·325 feet at an azimuth of 164° 12′ 47″, and the northwest corner of lot 17, concession VIII is distant 920.828 feet at an azimuth of 312° 21′ 11″.

The height of the lamp stand and top of tripod above the geodetic point are, respectively, 79·3 and 73·0 feet.

Carp, 1907.—This station is situated on a high bare-topped rock on the highest part of lot 17, concession II, of Huntley township. Carleton county, Ontario, about half a mile east from the village of Carp on the Grand Trunk railway, Parry Sound–Ottawa.

The station is marked by a copper bolt wedged in a hole in the rock. The observations were made from a 70-foot tower.

Bowesville, 1907–08.—This station is situated on the front of lot 12, concession 3, township of Gloucester, county of Carleton, province of Ontario. The property is owned by E. Jardine, whose house is one-quarter of a mile east of the station.

The geodetic station is marked by the point of a 4-inch spike protruding 1 inch above concrete in which it is set in a tile. It is placed $3\frac{1}{4}$ feet below the surface. Above this is a similar mark placed 9 inches below the surface. The northwesterly angle of lot is distant 109·6 feet at an azimuth of 296° 22′.

Observations were made from a 70-foot tower. The lamp stand and tripod head are 78·2 and 71·6 feet, respectively, above the near-surface mark. The post office is Bowesville.

Ashton, 1907.—This station is situated on lot 27, concession VIII, township Beckwith, Lanark county, province of Ontario, on land owned by Neil Stewart, Ashton post office.

A copper bolt is leaded in the rock 3 feet 6 inches below the surface of the ground. A flat stone covers the bolt, on which a 4-inch sewer pipe stands. The pipe is filled with concrete, with a small iron spike in the top for a surface mark about 14 inches below the general level of the ground. A tower with a 95-foot tripod was erected over this station.

The nearest railway station is Ashton on the Canadian Pacific railway, 23 miles southwest of Ottawa. The geodetic station is about one and a half miles southeast of the railway station—a short distance to the right of the main highway.

Groveton, 1907.—This station is situated on the west half of lot 23, concession IX, in the township of Edwardsburg, in the county of Grenville, Ontario.

The geodetic point is marked by the point of a 6-inch spike, head down, cemented into the top of a vertically placed 4-inch by 2-foot tile at a depth of 3 feet 9 inches below the surface. A near-surface mark of the same construction is placed 15 inches below the surface.

Observations were made from a 70-foot tower.

North Gower, 1907.—This station is situated on lot 17, concession III, of the township of North Gower, Carleton county, Ontario. The property is owned by Nixon Craig, North Gower.

The geodetic station is marked by the points of two spikes set in concrete in 4-inch tile. The upper tile comes within 9 inches of the surface, and the lower is 3 feet below the surface. Connection is made with a concrete witness monument at an azimuth of 346° 54′ 04″, and distant 262 feet from the geodetic point.

Observations from an 80-foot tower were made from this station in 1908.

Montague, 1907.—This station is situated on lot 4, of the 7th concession of Montague, county of Lanark, province of Ontario. The owner is Hugh Thompson, North Montague post office.

The geodetic point is marked on the upper surface of a copper bolt 6 inches long, placed in a hole drilled to a depth of 3 inches into the rock and concreted to within 1 inch of the top of the bolt. The top of the bolt is about 3 feet below the surface. A near-surface mark of the usual kind is paced 10 inches below the surface. A stone slab is placed over the subsurface mark.

Observations were made from this station from a 70-foot tower.

Ormond, 1907-08.—This station is situated on lot 5, concession XI of the township of Winchester, Dundas county, Ontario, which is the property of John McKinney Rodney, farmer, who lives about 300 yards east of the tower. The post office is Ormond.

The geodetic point is marked by the point of a spike in a layer of cement 8 inches thick, on a bed of rock 3½ feet below the surface. Above this is a 6-inch layer of sand, above which is another nail in the top of a 2-foot tile filled with cement, the upper end being 9 inches below the surface of the ground.

A reference monument is distant 191·69 feet at an azimuth of 261° 13′ 41″, and the northwest corner of the lot is distant 959·8 feet at an azimuth of 319° 38′ 07″.

The height of the lamp stand above the tripod top and the near-surface mark is 6·1 feet and 87·2 feet, respectively.

Dundela, 1907–08.—This station is situated on the east half of lot 2, concession V, of the township of Matilda, Dundas county, Ontario. The property is owned by Robert S. Merkley, and the post office is North Williamsburg.

The geodetic point is marked by underground and surface marks, each being the points of 6-inch spikes set in concrete in the top of a 6-inch tile, 2 feet long. Between the two tiles is 6 inches of dry sand. The top of the upper tiles is flush with the surface of the ground.

Connection is made with a concrete witness monument of the usual form situated in the northwesterly corner of an orchard, and being at an azimuth of 318° 59′ and distant 224·2 feet from the geodetic point.

Observations were made from a 70-foot tower in 1908.

Osnabruck, 1908.—This station is situated on the highest part of lot 28, concession V, of Osnabruck township, Stormont county, province of Ontario. Owner of property is A. S. Hodgins, Osnabruck Centre post office.

The station is marked by a copper bolt set in concrete four feet below the surface of the ground; a near-surface mark is placed directly over this, 12 inches below the surface of the ground.

The station is referenced to the southeast corner of the lot and to a concrete monument as follows:—

	Azimuth	Distance
Lot corner	143° 06′ 22″	1084′·75
Monument	143 21 33	1081′·68

The tripod is 81·7 feet above the near-surface mark, and the lamp stand 87·8 feet above the near-surface mark.

The nearest railroad station is Aultsville on the Grand Trunk railway, which is 6½ miles distant, or Finch on the Canadian Pacific railway and New York and Ottawa railway, which is 8 miles distant.

Sidney.—This station is situated a little to the south of the highest part of a heavily wooded ridge on the northerly end of lot 13, concession VI of the township of Sidney, in Hastings county, Ontario.

The geodetic point is marked by a copper pin set in concrete, 12 inches below the surface and referenced by three nails in a large oak tree as follows:—

	Azimuth	Distance
Oak tree	199° 28′	76·5 ft.

The station may be reached from either Stirling on the Grand Trunk railway, or Frankford on the Canadian Northern railway.

Ameliasburg (Secondary).—This station is situated on lot 97, concession IV (counting south from the Bay of Quinte, and being the concession adjoining the township of Hillier) of the township of Ameliasburg, Prince Edward county, Ontario.

The geodetic point is marked by a copper pin set in concrete 14 inches below the surface of the ground and referenced by three nails in a hickory tree (the centre one of five similar trees) close to the westerly line of the lot as follows:—

	Azimuth	Distance
Nails in tree	242° 43′	270·5 ft.

The point is also 251·5 feet from the westerly line of lot 97 and 2,718 feet from the intersection of the above line, with the northerly limit of the main road, which runs close to the north side of Consecon lake.

The station is reached by driving 2 miles easterly from Consecon on the Canadian Northern railway.

Note.—The concessions in the township of Ameliasburg are numbered at the present time from the Bay of Quinte southwards. The township maps show them numbered from the township boundary of Hillier northwards. For this reason the station has been described as above to avoid possible errors in locating it on the map.

Presqu'île Geodetic Station.—This station is 183·61 feet distant from Presqu'île lighthouse at the easterly end of Presqu'île peninsula (sometimes called island) which lies south of the township of Brighton, Northumberland county, Ontario, and is the station from which observations were originally made and on which observations from the other stations were made. As such it is the station which entered into the net adjustment.

From this station the station Presqu'île lighthouse was determined, it being distant 183·61 feet, at an azimuth of 108° 28′ 35″.

The station is reached by driving from Brighton around the beach or by boat from either Consecon or Brighton.

West Point.—This station is situated on the top of a steep sand hill about 90 feet above the level of lake Ontario, just to the north of the Lake Shore hotel, and about 300 feet from the lake, in the extreme southwesterly portion of the township of Hallowell, Prince Edward county, Ontario.

The geodetic point was marked by a copper wire set in concrete in a sewer tile 6 inches in diameter and 2 feet long, about one foot below the surface of the sand. The hill consists of drifting sand, and the geodetic point is not therefore likely to be permanent.

The station was referenced by connecting with one of the signals of the Hydrographic Survey and with the northeasterly corner of the most westerly subdivision of Hallowell township, where the West Lake road reaches lake Ontario. The connections are:—

	Azimuth	Distance
Hydrographic signal	236° 41′ 52″	24·12 metres
Lot corner	129 45 52	181·78 "

The most convenient railway station is Picton on the Canadian Northern railway, from which the geodetic station is reached by driving 12 miles southwesterly on the West Lake road.

Point Petre.—This station is the centre of Point Petre lighthouse, situated on the most southerly point of the township of Athol in Prince Edward county, Ontario.

The station is reached by driving 15 miles from Picton on the Canadian Northern railway southwesterly to Cherry Valley and then southerly on the Point Petre road which ends at the lighthouse.

Scotch Bonnet.—This station is the centre of Scotch Bonnet lighthouse, on the island usually called Scotch Bonnet, or sometimes Egg island, off the coast of Prince Edward county.

The island is about 400 feet long and 100 feet wide. It is solid rock, with a little soil on top, and is about 2 miles from the mainland and 1 mile from Nicholson's island, which lies between. The nearest part of the mainland is the southwesterly portion of the township of Hillier, county of Prince Edward, province of Ontario.

Scotch Bonnet may be reached from either Consecon or Wellington on the Canadian Northern railway.

INDEX

PAGE

Azimuth. See Geographic Co-ordinates.
Condition Equations, Absorption by Normal Equations 13
Condition Equations, Selection of Side and Angle 122
Condition Equations—
  Coteau Base Net 74
  King Mountain–Murray Net 146
  Rigaud–North Mountain Net 121
  Rigaud–Standon Net 111
Co-ordinate Adjustment.
  Development of Formulae 12
  Differential Formulae 12
  Successive Differential Solution 16
Co-ordinates, Preliminary 48
Corrections to Directions—
  Evaluation of Coteau Base Net 104
  Evaluation of King Mountain–Murray Net 157
  Evaluation of Rigaud–North Mountain Net 134
  Evaluation of Rigaud–Standon Net 116
Correlate Equations—
  Coteau Base Net 78
  King Mountain–Murray Net 152
  Rigaud–North Mountain Net 126
  Rigaud–Standon Net 116
Directions, Observed and Adjusted—
  Coteau Base Net 106
  Dusable–Haldimand Net 26
  King Mountain–Murray Net 158
  Ottawa–Groveton Net 62
  Rigaud–North Mountain Net 139
Descriptions 172
Distances. See Geographical Co-ordinates.
  See Length of Sides.
Effect on Triangulation of Base and Laplace Conditions—
  Dusable–Haldimand Net 25
Elevation, Corrections to Directions due to.
  King Mountain–Murray Net 146
  Rigaud–North Mountain Net 121
Final Values, Evaluation of—
  Ottawa–Groveton Net 60
  See Geographical Co-ordinates.
Geodetic Line, Correction to Directions due to.
  King Mountain–Murray Net 146
  Rigaud–North Mountain Net 121
Geographical Co-ordinates 162, 165
Lateral Refraction 111
Latitude. See Geographical Co-ordinates.
Length of Sides, Comparison of—
    Coteau Base Net 108
    Rigaud–North Mountain Net 143
    Rigaud–Standon Net 118
  Evaluation of—
    King Mountain–Murray Net 162
Longitude. See Geographical Co-ordinates.
Methods Used in Office to Refine Field Work 6
Methods Used in Office to Test Field Work 6
Normal Equations.
  Solution of—
    Coteau Base Net 82
  Tabulation of—
    Coteau Base Net 82
    King Mountain–Murray Net 154
    Ottawa–Groveton Net 56
    Rigaud–North Mountain 128
    Rigaud–Standon 116
O–C Test—
  Coteau Base Net 105
  King Mountain–Murray 162
  Rigaud–North Mountain 138
  Rigaud–Standon 117
Observation Equations—
  Dusable–Haldimand Net 21
  Ottawa–Groveton Net 50
Orientation Factor "Z".
  Ottawa–Groveton Net 51

INDEX—*Concluded*

	PAGE
Precision—	
Coteau Base Net	108
Dusable–Haldimand	19
King Mountain–Murray	163
Ottawa–Groveton	63
Rigaud–Standon	119
Scotch Bonnet	72
Precision Formulae—	
Ottawa–Groveton	59
Probable Error—	
King Mountain–Murray	159
Rigaud–Standon	120
Reduced Normal Equations—	
Coteau Base Net	103
King Mountain–Murray	156
Ottawa–Groveton	57
Rigaud–North Mountain	130
Reduction to Centre—	
Ottawa–Groveton	46
Spherical Excess—	
Coteau Base Net	74
Trinagles, Tabulated—	
Dusable–Haldimand Net	32
King Mountain–Murray Net	159
Ottawa–Groveton Net	64
Rigaud–North Mountain Net	140
Twist	17
Unknowns, Evaluation of—	
Coteau Base Net	103
King Mountain–Murray Net	157
Ottawa–Groveton Net	61
Rigaud–North Mountain Net	132
Weights—	
Rigaud–North Mountain Net	121

INDEX OF STATIONS

Station	Position Page	Descripton Page	Sketch Page
Ameliasburg	165	172	73
Ameliasburg (Secondary)	171	186	...
Alexandria	168	179	145
Alleyn	167	183	45
Ashton	170	184	69
Asphodel	165	172	45
Bastard	166	176	164
Bellevue	169	183	45
Blake	167	183	45
Bonville	168	178	69
Bowesville	170	184	69
Buckingham	167	178	45
Carp	170	184	69
Covey Hill	169	180	110
Crosby	166	175	164
Dundela	170	185	69
Dusable	169	181	45
East Base (Belleville)	165	173	45
East Base (Coteau)	168	179	110
Elizabethtown	166	176	69 164
North Elmsley	167	176	69 164
Grimsthorpe	168	174	45
Groveton	170	184	69
Haldimand	165	172	45
Hallowell	165	174	73
Hincks	167	182	45
Hull	167	181	45
Huntingdon	169	179	110 45
Kaladar	166	175	164
Kilkenny	169	180	...
King Mountain	167	177	69 164
Lansdowne	167	176	164
Lavant	166	175	69 164
Masham	167	182	45
Maxville	168	178	145
Methuen	165	172	45
Montague	171	185	69
Murray	165	172	73 164
Navan	168	178	69
Newton	168	179	110 145
North Gower	169	184	69
North Mountain	170	177	69 164
Oak Hill	166	174	...
Olden	166	175	164
Ormond	170	185	69
Osnabruck	170	185	69
Ottawa	167	183	69
Pakenham	169	184	69
Plantagenet	168	178	145
Point Petre	...	187	...
Portland	166	175	164
Presqu'ile	...	186	...
Rigaud	169	180	69 110
Mount Royal	169	183	110
Roxboro	168	177	69
Scotch Bonnet	171	187	73
Sidney	170	186	73
St. Armand	169	180	45
Tyendinaga	166	174	73
Vankleek	168	179	...
Wakefield	167	182	45
West Base (Belleville)	165	173	45
West Base (Coteau)	169	180	110
West Point	171	186	...
Yamaska	169	181	45

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GEODETIC SURVEY OF CANADA

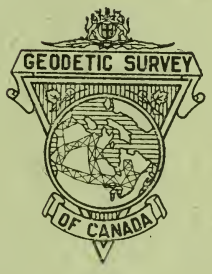
NOEL OGILVIE, *Superintendent*.

STANDARDS

DETERMINATION OF THE LENGTHS OF INVAR BASE LINE TAPES FROM STANDARD NICKEL BAR No. 10239

PUBLICATION No. 3

UNIVERSITY OF ILLINOIS
APR 3 1919



OTTAWA
J. DE LABROQUERIE TACHÉ
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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GEODETIC SURVEY OF CANADA
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CONTENTS

	Page.
Object of Geodesy	5
Operation of Geodesy	5
Measurement of Base Lines	5
National Prototype Bars	6
Geodetic Survey of Canada, Standards Building	7
Standards	7
Five-metre Bar and Ice Trough	8
Length of Comparator and Reference Tape	10
Determination of Length of Field Tapes	11
Tables:—	
1. May Determination of Length of 5-metre Bar No. 10239	13
2. Determination of Length of Comparator	14
3. Determination of Length of Tape No. 4252	15
4. Determination of Length of Tape No. 3141	15
5. Comparator from Reference Tapes 3141 and 4252	16
6. Tape No. 3140 from Reference Tapes 3141 and 4252	17
7. Tape No. 3139 from Reference Tapes 3141 and 4252	17
8. Tape 13814 from Reference Tapes 3141 and 4252	18
9. September Determination of Length of 5-metre Bar No. 10239	18
10. Length of Comparator from 5-metre Bar	20
11. Determination of Tape No. 4252 from 5-metre Bar	20
12. Deduced Length of Comparator from Tape 4252	21
13. Determination of Length of Tape 3141 from Tape 4252	21
14. Determination of Length of Tape 3140 from Tape 4252	22
15. Determination of Length of Tape 3139 from Tape 4252	22
16. Determination of Length of Tape 13814 from Tape 4252	22
17. Length of Comparator from 5-metre Bar	23
18. Determination of Length of Tape 4252 from 5-metre Bar	23
19. Deduced Length of Comparator from Tape 4252	24
20. Determination of Length of Tape 3141 from Tape 4252	24
21. Determination of Length of Tape 3140 from Tape 4252	25
22. Determination of Length of Tape 3139 from Tape 4252	25
23. Length of Tape 13814 from Reference Tape 4252	26
24. Length of 5-metre Bar at 0° C. and Tapes at 16°·5 C. from Standard Metre Bar 10239	26

STANDARDS OF THE GEODETIC SURVEY OF CANADA

by F. A. McDiarmid

Geodesy is the science of surveying extended to large tracts of country, having in view not only the production of a system of maps of very great accuracy, but the determination of the curvature of the surface of the earth and eventually of the figure and dimensions of the earth. This last, indeed may be the sole object in view as was the case in the operations conducted in Peru and in Lapland by the celebrated French astronomers, P. Bouguer, C. M. De La Candamine, A. C. Clarault and others, and the measurement of the meridian arc of France by Michain and Dalambre had for its determination the true length of the "Metre" which was to be the legal standard of length of France.

The basis of every extensive survey is an accurate triangulation, and the operation of geodesy consists in the measurement, by theodolites, of the angles of the triangles, the measurement of one or more sides of these triangles on the ground, the determination by astronomical observations of the azimuth of the whole network of triangles; the determination of the actual positions of the same on the surface of the earth by observations, first for latitude at some of the stations, and secondly for longitude and the determination of altitude for all the stations. The azimuth and longitude must always be observed at the same station, thus providing a Laplace determination to control the twist of the triangulation. For computation the points of the actual surface of the earth are imagined as projected along their respective plumb lines on the mathematical figure which is given by the stationary sea level and the extension of the sea through the continents by a system of imaginary canals.

For many purposes the mathematical surface is assumed to be a plane; in other cases a sphere of radius 6,371 kilometres (20,900,000 feet); in case of extensive operations the surface must be considered as a compressed ellipsoid of rotation, whose minor axis coincides with the earths axis and whose compression, flattening or ellipticity is about $\frac{1}{298}$.

MEASUREMENT OF BASE LINES

To determine by actual measurement on the ground the length of side of one of the triangles (Base Line), wherefrom to infer the length of all the other sides in the triangulation, is not the least difficult operation of a trigonometrical survey. When the problem is stated thus—to determine the number of times that a certain standard or unit of length is contained between two finely marked points on the surface of the earth, at a distance of some miles apart, so that the error of the result may be pronounced to lie between certain very narrow limits—then the question demands very serious consideration. The representation of the unit of length by means of the distance between two fine lines on the surface of a bar of metal at a certain temperature is never itself free from uncertainty and probable error, owing to the difficulty of knowing at any moment the precise temperature of the bar; the transference of this unit, or multiple of it, to a measuring bar will be affected not only with errors of observation, but with errors arising from uncertainty of temperature of both bars. If the measuring bar is not self-compensating for temperature, its expansion must be determined by very careful experiments. The thermometers required for this purpose must be very carefully studied, and their errors of division and index errors determined. In 1871 Mr. R. S. Woodward of the United States Coast and

Geodetic Survey invented his 5-metre ice bar, and for determining the lengths of the field tapes or wires used in measuring base lines, this 5-metre ice bar has been used since then. The introduction of the ice bar apparatus did away with all uncertainty of temperature of the bars used as standards. The length of the 5-metre bar was determined from the standard metre bar which was secured by the United States Government in 1799, and which had been standardized by the French committee in terms of the toise which had served as a standard unit in measuring the meridian arcs of France and Peru. The lengths of the chains or tapes used in measuring the bases in the field were determined from the lengths of this 5-metre bar. A distance of 100 metres was first carefully measured with the 5-metre ice bar, and then its length was determined with the tapes. The method of these comparisons will be explained later. In November of 1877, the United States Government received three platinum-iridium bars of the prototype metre standardized by the International Bureau at Paris, and from early in 1900 these have referred the Coast Survey standard to the International. The length of the iron metre bar was given in 1799 as 1 m $-$ 0.4 μ and from comparisons with the new bar its length in 1900 was 1 m $+$ 0.2 $\mu \pm$ 0.6 μ.

Probably a few words regarding these national prototype bars may be of interest. In the year 1870 the government of France invited the governments of the world to send delegates to Paris for the purpose of forming an international commission having for its object the construction of a new metre as an international standard of length. Owing to the unsettled political condition then prevailing in Europe, nothing was done until the second meeting in 1872, when a general plan was outlined and definite propositions as to the mode of procedure to attain the objects in view were adopted. The most important of these propositions were to make the International metre a line measure whose length at 0° C. should be equal to that of the Metre des Archives, and to use as the material for the standard an alloy of platinum-iridium containing 10% of iridium with a tolerance of 2% in excess or deficiency. On May 20, 1875, a metric convention was signed at Paris by the representatives of seventeen nations for the purpose of establishing and maintaining at the common expense a scientific and permanent International Bureau of Weights and Measures near Paris. By this treaty the operations of the International Bureau are put under the exclusive direction and supervision of an International Committee, which latter is under the control of a general conference composed of delegates from all the contracting governments. This International Bureau of Weights and Measures is charged with

(1) All comparisons and verifications of the new prototype of the metre and kilogramme.
(2) The custody of the International prototypes.
(3) The periodical comparison of the national standard with the International Prototypes, and with their test copies, as well as the comparison of standard thermometers.

After much experimenting and investigation an alloy was produced from which some thirty-one bars were made. The length of one of these at 0° C. was found equal to that of the Mètre des Archives, and it was selected as the International prototype. The other bars distributed to the different governments are called National Prototypes, and their lengths are obtained with the greatest degree of accuracy obtainable. The probable error of the comparison of the national bars with the International metre is ·04 μ where μ stands for micron or the millionth part of a metre.

As pointed out above, the United States government has three of these national prototypes. Two of them are known as Nos. 27 and 21. Some doubt as to whether there was any change in their lengths arose and in 1901 No. 27 was again compared with the International bar. The length in 1888 for No. 27 was 1 m.–1·55 μ at 0° C.

In 1901 the length of No. 27 was 1 m.–2·00 μ at 0° C., or there was an apparent shortening of ·45 μ. It is not the intention to discuss this apparent discrepancy. It is not vital to this report.

THE STANDARDS BUILDING

The standards building of the Geodetic Survey of Canada is a one-story building about one hundred and eighty feet long and twenty-five feet wide. It stands approximately north and south. The inside of the building is lined, walls and ceiling, with matched lumber. The floor is of concrete several inches thick. Down the centre runs the 50-metre comparator or base. This base is divided into ten equal parts by eleven piers placed at intervals of five metres. The last 5-metre space at the north end is divided into five equal parts by four intermediate piers. All these piers are insulated from the floor and made as free as possible from any external vibration. On the tops of the piers are placed cast iron plates with attachments for mounting and adjusting microscopes. These microscopes are mounted vertically on projecting arms, over the centre of a steel rail track on which two small cars may travel from end to end of the comparator. These cars are to carry a trough holding ice and water supporting the 5-metre bar which will be described later. The cars and trough can be moved along the track from pier to pier, and with the aid of controlling levers attached to the cars, may be held under the microscopes and the length of the base multiplied ten times, determining the absolute length of the 50-metre base in terms of the 5-metre bar. The 5-metre section at the north end of the 50-metre base is used for determining the length of the 5-metre bar in terms of the standard metre nickel bar. The rails of the track carrying the car are insulated from the concrete floor of the building so that no vibration may be communicated from the floor to the bar.

The ends of the 50-metre base are marked by bronze bolts set on end in concrete blocks which are projections of the end piers built up from the bottom, the tops of these bolts which are hemispherical are slightly below the floor level.

The microscopes on the end piers over the bolts are larger and more powerful than those on the intermediate piers, they are mounted permanently and provided with adjusting screws parallel and transverse to the base. The centres of the heads of these bronze bolts are the fiducial points of the base. To refer to these points, cylinders called "cut-offs" are used. They terminate at one end with conical holes which fit over the spherical heads. The other ends are fitted with transverse levels and graduated scales. The scales are brought by rack and pinion motion under the microscopes whose position relative to the fiducial points are sought.

The scales and levels which are parallel to one another are placed parallel to the line measured; with the cylinders thus placed readings of the micrometer on the scales and of the positions of the level bubble are made. The cylinders are then turned one hundred and eighty degrees in azimuth and the scale and level readings again observed. From these observations and the height of the scales above the bolt heads, the horizontal distances (in the direction of the line) between the micrometer zeros and the fiducial points may be determined.

Standards

The standard of length of the Geodetic Survey of Canada is a nickel bar, known as No. 10239. This bar is of H form section, total length about 102·6 cm., and length of side about 2·5 cm. The graduations are on the neutral plane of the bar, and are at each millimetre from 0 to 100 cm. A millimetre scale divided into tenths is added immediately beyond each end of the fundamental distance 0–100 cm.

Prof. R. T. Glazebrook of the National Physical Laboratory, Teddington, England, gives the actual length of the bar at 0° C. as 1·0000269 metres, and the length at a temperature t° C. has been found to be given by the formula: $Lt = L° (1 + 0·000,012,53t + 0·000,000,005,21t^2)$ the temperature being expressed in the hydrogen scale.

There are two other metre bars known as No. 10241A and 10241.

No. 10241A is of invar. Its length was also given by the National Physical Laboratory, but on account of the instability of the alloy, it has not been used. Also No. 10241 has not been used except as a check.

The length of the standard bar No. 10239, as stated above, was determined by Prof. Glazebrook, by comparing with the metre bar of the National Physical Laboratory, which in turn was determined from the International bar at Sevres near Paris. The standard of length of the Geodetic Survey of Canada is, therefore, based directly on the International metre.

FIVE-METRE BAR AND ICE TROUGH

The auxiliary standard of the Geodetic Survey of Canada is a 5-metre bar of tire steel, obtained from Washington in 1906. This bar is 5·02 m. long 1·8 mm. thick and 32 mm. deep. The upper half is cut away about 22 mm. at each end and platinum-iridium graduation plugs inserted with their upper surfaces in the neutral surface of the bar. One line transverse to the length of the bar, and two longitudinal lines are ruled on each plug. These transverse lines establish the ends of the measure. Eleven German silver plugs projecting slightly are inserted in the upper surface of the bar for alinement vertically by means of a striding level, and horizontally by stretching a fine wire along the top.

The 5-metre bar is mounted in a Y shaped trough known as the ice trough. This trough supports the bar, keeps it alined, and carries the load of ice and water essential to control the bar's temperature.

The sides of the trough, which are of steel plate bent to form an angle of 60°, are rivetted together. The bar is supported at every half metre of its length by saddles which are rigidly attached to the sides of the trough by screws. Each saddle carries one vertical and two lateral adjusting screws. These screws serve to fix the alinement of the bar. The lateral adjusting screws of the saddle at the ends of the bar are at the same heights and the lateral adjusting screws of the intermediate saddles are alternately high and low. The object of this disposition is, first, to prevent pinching the bar, which might occur if the screws were all opposite to each other, second to afford some means of rotating the bar slightly about its longitudinal axis. So that for a fixed and nearly vertical position of the trough the graduated surface of the bar may be made horizontal. The vertical adjusting screws of the saddle project below the vertex of the trough. The trough is very rigid with respect to vertical stresses, and is covered with a close fitting jacket of heavy padded cotton which protects the bar and load from direct radiation.

For measuring grade angles a sector reading by two opposite verniers is attached to one side of the trough near its middle point. The Y trough is mounted on two cars, the saddles of which are attached to the trough 40 cm. from either end, and which are provided with an adjustment, laterally, longitudinally and vertically for centering and focusing the ends of the bar under the microscopes. Up to the present time the 1-metre bar has been mounted in a wooden trough which rests on two supports placed on top of the 5-metre trough, but a new 1-metre ice trough is in process of making.

The neutral horizontal plane of the metre bar is made parallel to the neutral plane of the 5-metre bar, and is also placed in the same vertical plane.

When the apparatus is in use the trough is filled with ice and water. Brass tubes with suitable rubber washers are adjusted over the end graduations of the bars, and the bars are then completely covered with ice and water.

The 5-metre bar is first placed in alinement by means of a fine thread run from end to end of the trough. The centres of the tops of the plugs in the top of the bar are placed directly under the thread. The bar is placed in a horizontal plane by means of a striding level which reaches from any one plug to the third, a distance of 999 cm.

After having both bars carefully adjusted, it is absolutely necessary that both be at 0° C. Experience has shown that the two bars should be in a solution of ice and water nearly forty-eight hours before it is well to commence observations. When both bars have been a sufficient time in the solution of melting ice, the microscope at the south end of the 5-metre space at the north end of the 50-metre comparator is set at some arbitrary setting. The graduation on the south end of the 5-metre bar is then, by means of the levers and adjusting screws brough to be covered by the wires in the microscopes. The north end of the 5-metre bar is then brought into adjustment with the north end microscope of the 50-metre comparator. When the 5-metre bar is thus perfectly adjusted under the microscopes, the cars carrying the trough and bars are then clamped to the rails. Simultaneously, observers at either end set the micrometer wires on the bar graduations and make the readings which are recorded. Five pairs of readings are made and then the observers change ends and make five other pairs. In this way any personal equation errors will be eliminated. The mean of the ten readings will be the position of the zeros of the microscopes with relation to the 5-metre bar.

The level of the sector is adjusted and the verniers read. One such set of readings will give the distance between the zeros of the two microscopes in terms of one length of the 5-metre bar, the micrometer reading and the sector reading. The trough is then lowered and the south end of the 1-metre bar is brought under the south microscope, and the north end of the bar is adjusted with respect to the microscope on the next pier. Then readings are taken on the metre bar following the same programme as with the 5-metre bar. The car is then moved one space north and the graduation on the south end of the metre bar is brought into adjustment under the micrometer wires of the second microscope, and the second space is measured in exactly the same way. This operation is repeated until the whole five spaces are occupied. Thus the distance between zeros of the microscopes on the south and the north ends of the 5-metre bar space is determined in terms of five lengths of the 1-metre bar, the small difference of the intermediate microscopes, the readings of the end microscopes and the sector readings on the spaces. Comparison of this result with that obtained from the 5-metre bar, will give an equation to determine the length of the 5-metre bar in terms of the length of the 1-metre bar.

If S and N be the micrometer readings on south and north end respectively, of the 5-metre bar, and F the correction for sector, and L the length of the 5-metre bar, then the distance between the zero of the south and north microscopes $= L + F + (N-S)$ - - - - - (1).

If s_1 and n_1, s_2 and n_2, s_3 and n_3, s_4 and n_4, s_5 and n_5 be the micrometer recordings on the south and north ends of the several metre spaces; f_1, f_2, f_3, f_4, f_5 the corrections for the sector, and 1 the length of the 1-metre bar, then the difference between the zeros of the end microscopes of the 5-metre space $= 5l + f_1 + f_2 + f_3 + f_4 + f_5 + (n_1 + n_2 + n_3 + n_4 + n_5) - (s_1 + s_2 + s_3 + s_4 + s_5)$ ..... (2)

Equating (1) and (2) there obtains

$$L + F + (N-S) = 5l + f_1 + f_2 + f_3 + f_4 + f_5 - s_1 + (n_1 - s_2) + (n_2 - s_3) + (n_3 - s_4) + (n_4 - s_5) + n_5 \quad \ldots\ldots (3)$$

or

$$L = 5l + (f_1 + f_2 + f_3 + f_4 + f_5 - F) + (S - s_1) + (n_1 - s_2) + (n_2 - s_3) + (n_3 - s_4) + (n_4 - s_5) + n_5 - N \quad \ldots\ldots (4)$$

Now S and s, are made as nearly equal as possible, being starting points for

both bars, also n_1 and s_2, n_2 and s_3, n_3 and s_4, n_4 and s_5 are nearly equal. This causes the value of L to depend nearly on the value of 1 and the value of (n_5 − N) the difference of the readings on the north microscope. Usually twelve such sets of observations are taken and an error of very small dimensions will show in the mean result.

The following tables, Nos. (1) and (9) show the results of the comparisons of the 1- and 5-metre bars, which were taken in May and September of 1917.

LENGTH OF COMPARATOR AND REFERENCE TAPE

Having determined the length of the 5-metre bar the next step is to obtain the length of the reference tape. There are five invar tapes of the Geodetic Survey of Canada. Three of these Nos. 3139, 3140 and 3141 are used in the field work, and two Nos. 4252 and 13814 are employed as reference tapes. The length of the reference tape No. 4252 is first determined from the 5-metre bar and then the lengths of the other four tapes are found by comparison with the reference tape. In determining the length of the reference tape the following operations are carried out. The length of the 50-metre comparator is first found in terms of ten lengths of the 5-metre bar. The position of the microscope relatively to the fiducial point at one end, say the south end of the comparator having been observed, the trough carrying the 5-metre bar is brought under the microscopes and the graduation on the south end of the bar is brought between the wires of the south end microscope and by means of a lever the south end observer holds the bar near to bisection while the north end observer brings the north end graduation under the microscope at the north end of the bar. When the bar and microscopes are adjusted, the south end observer brings the south end graduation accurately to bisection by use of his lever without turning the micrometer screw. Simultaneously he gives the signal "point" to the north end observer who brings his micrometer wire to bisect the north end graduation. The observers then read the micrometers and the recorder notes the readings. The observers change ends and repeat the operation. The north microscope of the pair is then set at the mean of the two readings of the north end of the bar; the bar is moved on to the next space and so on until the different spaces of the comparator are occupied. The grade sector is read on each space, and a correction for sector is applied. The values of the micrometer screws are accurately known. The north end cut-off is read and the zero of the microscope with reference to the fiducial point is determined.

If C s and C n are the cut-off readings on the south and north ends of the comparator, and Bs and Bn are the bar readings at the south and north ends, and f 1, f 2, f 3 − − − f 10 are the sector corrections on the different spaces, and L the length of the 5-metre bar, then the length of the comparator is given by the equation $C = 10L + (Bn - Bs)m + (Cs - Cn)\,m + f_1 + f_2 + f_3 - - - f_{10}$; where M is the value of the micrometer screws in microns. Having made the trip from the south to the north microscope with the 5-metre bar in a solution of melting ice, the trough is removed from the truck. In comparing the tape with the comparator, the following procedure is followed: The zeroes of the end microscopes are first determined with reference to the fiducial points, on the head of the bolt, marking the ends of the comparator. The reference tape No. 4252 is placed in position under the microscopes. The tapes are always used under a tension of fifteen kilogrammes over frictionless pulleys and supported at the centre by a frictionless race. Small wooden blocks are set on the tops of the cut-offs, and the cut-off tubes are so adjusted that when the tape just clears these blocks the graduations on the tapes are in focus in the microscopes. The graduations on the tapes do not run entirely across the tapes, they cut the edge of the tape at one side and run nearly to the other edge. When the tape is in position

and adjusted observations begin. One of the observers moves the tape or say "pushes" the tape. When he is ready he calls "ready" to the observer at the other end of the comparator. At this signal the second observer, by a slight pressure of the finger, brings the tape to rest, and on the signal, "point", both observers set their micrometer wires on the graduation at their respective ends. The micrometer readings are made and recorded. Five such pairs of readings are observed and the observers change ends, reading the thermometers as they travel from end to end of the comparator. For the second five pairs of readings the same observer handles the tape and instead of "pushing" the tape now "pulls" it. The ten pairs constitute a full set.

If C = length of comparator determined from the 5-metre bar, C s and C n be the cut-off readings at south and north ends of comparator, and T s and T n the mean of the ten readings on the south and north ends of the tape respectively, and t° C the mean of the temperature readings, the length of the tape at t° C, is given by l t° = C + (T s − T n) M + (C n − C s) M; and length at 16°·5 C is given by l 16·5° = C + (T s − T n) M + (C n − C s) M + (16·5 − t)α; α being the unit of dilatation fo reach degree centigrade for the particular tape under observation.

After six such sets are taken on the tape, it is removed from under the microscope and the length of the comparator again determined with the 5-metre bar. This time the journey along the comparator is made from north to south. For a complete determination of the length of a reference tape four such groups should be taken; *i.e.*, length of comparator four times forward and back and six readings on the tape between each pair of journeys of the bar. In this manner twenty-four determinations of the length of the tape are obtained. In tables 2, 10 and 17 are given the lengths of the comparator from the 5-metre bar and in tables 3, 4, 11 and 18 are found the lengths of the reference tapes deduced as described above. In the observations taken in May the two tapes Nos. 4252 and 3141 were deduced directly from the 5-metre bar, and were used as reference tapes to determine the length of the other three tapes. In the September and November observations tape No. 4252 was used alone as the reference tape.

DETERMINATION OF LENGTH OF FIELD TAPES

When observing with tapes in the field the temperature of the tapes is secured from two thermometers which are clamped to the tapes one metre from either end. In standardizing the tapes the thermometers are always placed on the tapes exactly as in the field, and the following series of observations are carried out in the intercomparison of tapes.

The reference tape No. 4252, whose length has already been determined, is placed under the microscope and the length of the comparator is derived from the assumed length of the reference tape. If C r is the length of the reference tape at 16°·5 C, and t is the temperature of observaton, T s and T n the south and north readings of the microscope on the tape graduation and C s and C n the south and north cut-off readings, then the length of the comparator is given by C = l r − (16·°5 − t) α − (Ts − Tn) M + (Cs − Cn) M, where α is the unit of dilatation for each degree Centigrade for the tape in use.

The reference tape is then replaced by one of the other tapes say No. 3141 and its length with reference to the comparator is determined.

The other three tapes are similarly observed and then the reference tape No. 4252 a second time. This constitutes a complete set.

The length of the comparator is determined from the length of the reference tape No. 4252 and the lengths of Nos. 3139, 3140, 3141 and 13814 are deduced from this determined length of the comparator. All personal errors of the observers are eliminated by exchanging ends at each half set, and any errors of pressure due to pulling or pushing the tape will also be thrown out. If possible

the observer who does the pulling and pushing should be the one who uses the tapes in the base observations. Then the tape will be handled under exactly similar conditions as when measuring the base. For a complete determining of the tapes twelve such comparisons are made for each tape. The deduced length of the comparator from the tape No. 4252 for the several observations during the past year are shown in tables 5, 12 and 19. The lengths of tape No. 3141 are given in tables 4, 13 and 20. Those of tape No. 3140 are in tables 6, 14 and 21. Those of tape No. 3139 are in table 7, 15 and 22, and those of tape No. 13814 in tables 8, 16 and 23.

A comparison of the length of the 5-metre bar and the several invar tapes at the several determinations will be of interest and are shown in table No. 24. It will be seen in examining this table that the length of the 5-metre bar has remained fairly constant as should be expected. The range of values is not more than one would expect from errors of observations or from errors of alinement. If there should be any appreciable error of alinement it will have no effect when transferred to the tape, for all that concerns is the distance between the end graduations of the 5-metre bar. If there is a bend in the bar it of course will be shortened a certain amount, but there will be a corresponding increased correction from the micrometer readings in determining the length of the comparator. It is, however, interesting to note this check between the lengths of the 5-metre bar as given by Washington, and the length as obtained in Ottawa from the standard nickel bar No. 10239. The Washington length was 4·9999464 metres and the mean of the length for the several observations at Ottawa is 4·9999486 metres, a difference of only one part in nearly two and one-quarter millions. There are quite large changes in the length of the tapes from time to time. Prof. R. T. Glazebrook of the National Physical Laboratory, Teddington, England, in speaking of invar tapes says: "We have not found any tape yet that has changed at a regular rate. All these tapes or wires used for base measurement are very delicate, and are liable to change in length due to some treatment to which they may be submitted, and this usually altogether outweighs any change that may result from regular molecular alteration. For instance, slight jars in handling may result in molecular changes, or even in small kinks or twists in the tape, which may be accompanied by alterations in length." Prof. Glazebrook also strongly recommends that tapes used in measuring Geodetic Survey base lines should be compared with the standards before, during and after the measuring of the base. This seems the only method to pursue if the work is to have the required degree of accuracy. The errors coming from outside sources as injury to tapes are likely to be far larger than any errors of observation. In the report of the United States Coast and Geodetic Survey for 1900 the following directions regarding tapes were given: "You will standardize each tape . . . on a hundred metre comparator. The length of the comparator to be found by measuring it with an iced bar . . . In computing the lengths of the tapes the length of the comparator shall not be assumed constant, but will be assumed to be that given by the measurement with iced bar by means of the last preceeding and first following measurements." This is the practice which it is the intention of the Geodetic Survey of Canada to follow, and will insure the length of our base lines accurate to a very high degree.

TABLE 1

DETERMINATION OF LENGTH OF 5-METRE BAR FROM STANDARD NICKEL BAR NO. 10239

LENGTH OF NICKEL BAR=1·0000269 METRES

Date and Time	Microscope	1-metre Bar			5-metre Bar			5 Lengths of 1-metre Bar	Corrections			Length of 5-Metre Bar.
		South	North	S–N	South	North	S–N		bs-bn	Bs - Bn	Sector	
1917				μ			μ	Metres	μ	μ	μ	Metres
May 16...	IV	944·2	.....	−932·4	943·3	.....	931·5	5·0001345	418·0	−604·9	−1·65	4·9999460
	V	2546·4	2550·1	3·6	.....	.....	.....	.....	.....	.....	.....	.....
a.m.	II	2155·1	2155·9	·8	.....	.....	.....	.....	.....	.....	.....	.....
11.30	III	1971·5	1965·8	− 5·5	.....	.....	.....	.....	.....	.....	.....	.....
	V	1486·8	1493·6	6·6	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	1781·8	1344·9	.....	2035·5	−1536·4	.....	.....	.....	.....	.....
	VI	.....	1782·3	1345·2	.....	2035·8	−1536·6	5·0001345	417·5	−610·1	− ·9	4·9999410
	V	2674·2	2669·5	− 46·0	.....	.....	.....	.....	.....	.....	.....	.....
12.15	III	1957·1	1956·2	− ·9	.....	.....	.....	.....	.....	.....	.....	.....
	II	2147·4	2146·9	− ·5	.....	.....	.....	.....	.....	.....	.....	.....
	V	1038·4	1035·5	− 2·8	.....	.....	.....	.....	.....	.....	.....	.....
	IV	930·5	.....	−918·9	938·2	.....	926·5	.....	.....	.....	.....	.....
	IV	944·4	.....	−932·6	939·5	.....	927·8	5·0001345	438·1	−617·9	− ·8	4·9999539
	V	1053·9	1058·3	4·3	.....	.....	.....	.....	.....	.....	.....	.....
12.30	II	2165·2	2161·1	− 4·0	.....	.....	.....	.....	.....	.....	.....	.....
	III	1976·4	1978·0	1·6	.....	.....	.....	.....	.....	.....	.....	.....
	V	1003·3	1603·0	− 3·0	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	1813·9	1369·1	.....	2047·8	1545·7	.....	.....	.....	.....	.....
						2061·1	−1555·7					
May 16...	VI	.....	1809·0	1365·4	.....	2049·9	−1547·3	5·0001345	437·0	−618·6	−1·0	4·9999519
	V	383·1	382·4	− ·7	.....	.....	.....	.....	.....	.....	.....	.....
p.m.	III	1969·2	1972·3	3·1	.....	.....	.....	.....	.....	.....	.....	.....
3.25	II	2161·9	2163·7	1·8	.....	.....	.....	.....	.....	.....	.....	.....
	V	1752·5	1751·1	− 1·4	.....	.....	.....	.....	.....	.....	.....	.....
	IV	943·0	.....	−931·2	945·4	.....	933·6					
					944·0	.....	932·2	.....	.....	.....	.....	.....
					945·4	.....	933·6					
	IV	943·4	.....	−931·6	945·4	.....	933·6	5·0001345	436·1	−619·6	− ·6	4·9999504
	V	1755·8	1752·9	− 2·8	.....	.....	.....	.....	.....	.....	.....	.....
3.30	II	2159·8	2165·5	5·6	.....	.....	.....	.....	.....	.....	.....	.....
	III	1967·1	1971·8	4·7	.....	.....	.....	.....	.....	.....	.....	.....
	V	1991·6	1989·9	− 1·7	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	1804·3	1361·9	.....	2061·1	−1555·7	.....	.....	.....	.....	.....
						2054·5	−1550·7					
						2054·5	−1550·7					
	VI	.....	1802·4	1360·5	.....	2060·7	−1555·4	5·0001345	433·1	−617·6	− ·6	4·9999494
	V	2259·5	2259·2	− ·3	.....	.....	.....	.....	.....	.....	.....	.....
4.15	III	1968·7	1972·0	+ 3·3	.....	.....	.....	.....	.....	.....	.....	.....
	II	2160·6	2162·8	+ 2·2	.....	.....	.....	.....	.....	.....	.....	.....
	V	2080·7	2080·8	+ ·1	.....	.....	.....	.....	.....	.....	.....	.....
	IV	944·5	.....	−932·7	945·4	.....	933·6					
					949·1	.....	937·2	.....	.....	.....	.....	.....
May 18...	IV	947·3	.....	−935·5	947·3	.....	935·5	5·0001345	448·6	−631·3	− ·9	4·9999509
	V	2094·6	2096·1	1·5	.....	.....	.....	.....	.....	.....	.....	.....
a.m.	II	2169·4	2172·7	3·3	.....	.....	.....	.....	.....	.....	.....	.....
11.40	III	1983·2	1984·4	1·2	.....	.....	.....	.....	.....	.....	.....	.....
	V	1332·7	1333·1	·4	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	1825·3	1377·7	.....	2075·8	−1566·8	.....	.....	.....	.....	.....
	VI	.....	1824·7	1377·3	.....	2070·62	−1562·9	5·0001345	446·7	−631·3	− ·8	4·9999491
	V	1257·5	1259·6	2·1	.....	.....	.....	.....	.....	.....	.....	.....
12.25	III	1983·1	1982·0	− 1·1	.....	.....	.....	.....	.....	.....	.....	.....
	II	2167·9	2165·5	− 2·4	.....	.....	.....	.....	.....	.....	.....	.....
	V	1600·5	1601·5	+ 1·0	.....	.....	.....	.....	.....	.....	.....	.....
	IV	942·0	.....	−930·2	943·4	.....	931·6	.....	.....	.....	.....	.....
	IV	941·0	.....	−929·2	939·5	.....	927·8	5·0001345	447·7	−630·6	− ·9	4·9999507
	V	1602·4	1601·9	− ·5	.....	.....	.....	.....	.....	.....	.....	.....
p.m.	II	2165·5	2168·1	2·6	.....	.....	.....	.....	.....	.....	.....	.....
2.30	III	1979·7	1977·4	− 2·3	.....	.....	.....	.....	.....	.....	.....	.....
	V	2093·7	2093·2	− ·5	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	1825·1	1377·6	.....	2064·62	−1558·4	.....	.....	.....	.....	.....

TABLE 1—*Continued*

DETERMINATION OF LENGTH OF 5-METRE BAR FROM STANDARD NICKEL BAR NO. 10239

Date and Time	Microscope	1-metre Bar			5-metre Bar			5 Lengths of 1-metreBar	Corrections			Length of 5-metreBar
		South	North	S–N	South	North	S–N		bs-bn	Bs - Bn	Sector	
1917				μ			μ	Metres	μ	μ	μ	Metres
May 18...	VI	.....	1825·1	1377·6	.....	2067·62	−1560·6	5·0001345	440·4	−628·5	− ·7	4·9999457
p.m.	V	1372·1	1374·9	2·8	.....	.....	.....	.....	.....	.....	.....	.....
3.08	III	1986·7	1983·9	− 2·8	.....	.....	.....	.....	.....	.....	.....	.....
	II	2171·8	2171·5	− ·3	.....	.....	.....	.....	.....	.....	.....	.....
	V	1634·6	1633·2	− 1·4	.....	.....	.....	.....	.....	.....	.....	.....
	IV	947·3	.....	−935·5	943·85	.....	932·1	.....	.....	.....	.....	.....
	IV	949·9	.....	−938·1	942·5	.....	930·7	5·0001345	443·7	−627·3	− ·7	4·9999502
	V	1637·8	1637·9	·1	.....	.....	.....	.....	.....	.....	.....	.....
	II	2180·4	2181·2	·8	.....	.....	.....	.....	.....	.....	.....	.....
3.40	III	1989·8	1989·3	− ·5	.....	.....	.....	.....	.....	.....	.....	.....
	V	1788·5	1790·1	1·6	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	1828·1	1379·8	.....	2064·1	−1558·0	.....	.....	.....	.....	.....
											Mean	4·9999490

TABLE 2

DETERMINATION OF LENGTH OF COMPARATOR FROM 5-METRE BAR

Date	Time	Temp. C.	Microm. Readings				10 Lengths of 5-metre Bar	Microm. Corr.		Length of Comparator
			5-metre Bar		Cut-off			Bar	Cut-off	
			South	North	South	North				
1917	a.m.	°					Metres	μ	μ	Metres
May 9.....	11.45	11·69	1,200·0	2,871·5	1,643·6	1,469·1	49·999490	1,263	132	50·000888
	12.10	.....	1,214·5	2,871·5	.....	.....	49·999490	1,252	132	50·000874
									Mean	50·000880
	p.m.									
May 9.....	4.27	12·5	1,287·0	3,006·0	1,643·6	1,469·1	49·999490	1,299	132	50·000921
	4.55	.....	1,281·0	3,006·0	.....	.....	49·999490	1,304	132	50·000926
									Mean	50·000924
	a.m.									
May 10.....	10.49	11·8	1,200·0	2,893·0	1,649·4	1,467·9	49·999490	1,279	137	50·000906
	11.24	11·8	1,494·0	2,893·0	.....	.....	49·999490	1,284	137	50·000911
									Mean	50·000909
	p.m.									
May 10.....	3.25	11·9	1,200·0	2,857·0	1,645·9	1,471·3	49·999490	1,251	132	50·000873
	3.53	11·9	1,198·5	2,857·0	.....	.....	49·999490	1,252	132	50·000874
									Mean	50·000874
	a.m.									
May 11.....	10.47	9·4	1,200·0	2,842·5	1,647·0	1,468·7	49·999490	1,241	135	50·000866
	11.15	9·4	1,227·5	2,842·5	.....	.....	49·999490	1,220	135	50·000845
	p.m.								Mean	50·000856
May 11.....	2.57	10·3	1,200·0	2,874·5	1,647·0	1,468·7	49·999490	1,265	135	50·000890
	3.27	10·3	1,228·5	2,874·5	.....	.....	49·999490	1,244	135	50·000869
									Mean	50·000879

TABLE 3

DETERMINATION OF LENGTH OF TAPE 4252 FROM 5-METRE BAR

Date.	Tape	Time	Temp.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.			
			C.	South	North	South	North		Tape	Cut-off	Temp.	
1917		a.m.	°					Metres	μ	μ	μ	Metres
May 9...	4252	9.39	11·71	1565·8	1944·4	1643·6	1469·1	50·000859	— 285	— 132	154	50·000596
" 9...	4252	9.58	11·55	1941·9	2343·8	1643·6	1469·1	50·000863	— 303	— 132	159	50·000587
" 9...	4252	10.28	11·46	2025·3	2397·1	1643·6	1469·1	50·000866	— 280	— 132	162	50·000616
" 9...	4252	12.34	11·69	1614·1	2053·6	1643·6	1469·1	50·000885	— 332	— 132	155	50·000576
" 9...	4252	3.04	12·49	1832·0	2253·6	1643·6	1469·1	50·000910	— 319	— 132	129	50·000588
" 9...	4252	3.32	12·55	2148·3	2556·3	1643·6	1469·1	50·000914	— 308	— 132	127	50·000601
" 9...	4252	5.19	12·56	1596·0	1977·5	1643·6	1469·1	50·000931	— 288	— 132	127	50·000638
May 10...	4252	9.40	11·69	1707·1	2115·8	1649·4	1467·9	50·000920	— 309	— 137	155	50·000629
" 10...	4252	9.57	11·72	1753·1	2130·1	1649·4	1467·9	50·000919	— 285	— 137	154	50·000651
" 10...	4252	11.56	11·71	1890·5	2222·2	1649·4	1467·9	50·000903	— 251	— 137	154	50·000669
" 10...	4252	12.19	11·77	1695·9	2103·6	1649·4	1467·9	50·000900	— 308	— 137	152	50·000607
" 10...	4252	2.15	11·87	1593·1	1943·4	1645·9	1471·3	50·000885	— 265	— 132	148	50·000636
" 10...	4252	2.45	11·90	1594·8	2031·3	1645·9	1471·3	50·000881	— 330	— 132	147	50·000566
" 10...	4252	2.55	11·87	1706·7	2148·7	1645·9	1471·3	50·000880	— 334	— 132	148	50·000562
" 10...	4252	4.26	11·75	1730·0	2126·4	1645·9	1471·3	50·000868	— 300	— 132	152	50·000588
May 11...	4252	9.40	9·08	1140·1	1582·2	1647·0	1468·7	50·000849	— 334	— 135	239	50·000619
" 11...	4252	9.56	9·39	2022·5	2436·2	1647·0	1468·7	50·000850	— 312	— 135	229	50·000632
" 11...	4252	11.58	9·98	2039·9	2506·5	1647·0	1468·7	50·000861	— 353	— 135	210	50·000583
" 11...	4252	12.15	9·99	1775·1	2246·7	1647·0	1468·7	50·000862	— 356	— 135	210	50·000581
" 11...	4252	2.03	10·16	1766·0	2218·3	1647·0	1468·7	50·000873	— 342	— 135	204	50·000600
" 11...	4252	2.23	10·16	1606·7	2038·6	1647·0	1468·7	50·000875	— 326	— 135	204	50·000618
" 11...	4252	3.55	10·30	1870·2	2348·6	1647·0	1468·7	50·000883	— 361	— 135	199	50·000586
" 11...	4252	4.10	10·46	1747·1	2258·7	1647·0	1468·7	50·000884	— 387	— 135	194	50·000556
											Mean	50·000604

TABLE 4.

DETERMINATION OF LENGTH OF TAPE 3141 FROM 5-METRE BAR.

Date	Tape	Time	Temp.	Microm. Readings				Length of Comparators	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.			
			C.	South	North	South	North		Tape	Cut-off	Temp.	
1917		a.m.	°					Metres.	μ	μ	μ	Metres
May 9....	3141	9.50	11·564	1922·0	2346·7	1643·6	1469·1	50·000860	— 321	— 132	315	50·000722
" ...	3141	10.13	11·47	2316·4	2766·2	1643·6	1469·1	50·000864	— 340	— 132	321	50·000713
" ...	3141	10.38	11·44	2011·1	2453·3	1643·6	1469·1	50·000868	— 334	— 132	323	50·000725
" ...	3141	10.45	11·72	1470·8	1888·2	1643·6	1469·1	50,000887	— 315	— 132	305	50·000745
" ...	3141	3.15	12·51	1974·1	2429·6	1643·6	1469·1	50·000911	— 344	— 132	255	50·000690
" ...	3141	3.43	12·54	2149·9	2552·9	1643·6	1469·1	50·000915	— 305	— 132	253	50·000731
" ...	3141	5.29	12·555	1852·9	2218·0	1643·6	1469·1	50·000932	— 276	— 132	252	50·000776
May 10...	3141	9.50	11·691	1753·1	2183·9	1649·4	1467·9	50·000919	— 326	— 137	307	50,000763
" 10...	3141	10.08	11·70	1498·6	1965·5	1649·4	1467·9	50·000917	— 354	— 137	306	50·000732
" 10...	3141	12.05	11·83	1591·1	2021·2	1649·4	1467·9	50·000901	— 325	— 137	298	50·000737
" 10...	3141	12.10	11·87	1543·1	1945·4	1649·4	1467·9	50·000901	— 304	— 137	295	50·000755
" 10...	3141	2.25	11·873	1570·9	2062·0	1645·9	1471·3	50·000883	— 371	— 132	296	50·000676
" 10...	3141	2.30	11·90	1527·2	2028·2	1645·9	1471·3	50,000882	— 380	— 132	293	50·000663
" 10...	3141	4.35	11·77	1805·9	2213·6	1645·9	1471·3	50·000865	— 312	— 132	302	50·000723
May 11...	3141	9.49	9·26	1560·2	2173·3	1647·0	1468·7	50·000850	— 461	— 135	464	50·000718
" 11...	3141	10.05	9·47	1879·8	2438·6	1647·0	1468·7	50·000851	— 422	— 135	450	50·000744
" 11...	3141	11.46	9·93	1815·4	2318·2	1647·0	1468·7	50·000860	— 379	— 135	420	50·000766
" 11...	3141	12.05	9·97	1935·6	2519·3	1647·0	1468·7	50·000862	— 440	— 135	418	50·000705
" 11...	3141	2.11	10·14	1557·2	2106·1	1647·0	1468·7	50·000873	— 415	— 135	408	50·000731
" 11...	3141	2.30	10·34	1523·6	2038·5	1647·0	1468·7	50·000875	— 389	— 135	395	50·000746
" 11...	3141	4.05	10·42	1806·7	2351·1	1647·0	1468·7	50·000884	— 412	— 135	390	50·000727
" 11...	3141	4.20	10·47	1671·8	2190·0	1647·0	1468·7	50·000885	— 393	— 135	386	50·000743
											Mean	50·000729

TABLE 5.

DEDUCED LENGTH OF COMPARATOR FROM REFERENCE TAPES 4252 AND 3141

Date	Reference Tape	Time	Temp.	Microm. Readings				Length of Tape at 16°·5 C.	Corrections			Length of Comparator
				Tape		Cut-off			Microm.		Temp.	
			C.	South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres.	μ	μ	μ	Metres.
April 25..	4252	10.03	6·37	2042·7	2532·0	1648·5	1460·5	50·000604	370	142	— 327	50·000789
" 25..	3141	10.24	6·42	1601·0	2303·6	1648·5	1460·5	50·000729	531	142	— 649	50·000753
" 25..	4252	11.30	6·49	1938·7	2382·1	1648·5	1460·5	50·000604	335	142	— 323	50·000758
Mean.....	.....	10.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000767
April 25..	4252	2.53	7·59	2355·2	2722·5	1648·5	1460·5	50·000604	278	142	— 288	50·000736
" 25..	3141	3.07	7·61	1915·2	2458·1	1648·5	1460·5	50·000729	410	142	— 572	50·000709
" 25..	4252	3.55	7·59	1825·1	2196·6	1648·5	1460·5	50·000604	281	142	— 288	50·000739
Mean.....	.....	3.18	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000728
April 26..	4252	9.55	5·62	1962·3	2472·3	1645·2	1461·6	50·000604	385	139	— 351	50,000777
" 26..	3141	10.20	5·72	1416·3	2160·2	1645·2	1461·6	50·000729	562	139	— 695	50·000735
" 26..	4252	11.35	5·98	1903·6	2385·7	1645·2	1461·6	50·000604	364	139	— 340	50·000767
Mean.....	.....	10.37	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000760
April 26..	4252	2.25	5·99	1931·9	2391·2	1645·2	1461·6	50·000604	347	139	— 339	50·000751
" 26..	3141	2.35	6·12	1896·2	2648·8	1645·2	1461·6	50·000729	569	139	— 668	50·000769
" 26..	4252	3.45	6·24	2124·4	2613·6	1645·2	1461·6	50·000604	370	139	— 331	50·000782
" 26..	4252	4.05	6·24	2332·8	2834·9	1645·2	1461·6	50·000604	379	139	— 331	50·000791
Mean.....	.....	3.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000773
April 30..	4252	11.36	9·87	1962·8	2403·4	1658·9	1460·7	50·000604	333	150	— 214	50·000873
" 30..	3141	11.59	9·88	2079·1	2554·6	1658·9	1460·7	50·000729	359	150	— 424	50·000814
Mean.....	.....	11.43	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000844
April 30..	4252	2.12	10·2	1956·9	2379·4	1658·9	1460·7	50·000604	317	150	— 203	50·000868
" 30..	3141	2.25	10·4	2124·3	2555·3	1658·9	1460·7	50·000729	326	150	— 390	50·000815
" 30..	3141	5.10	10·7	2110·8	2548·9	1658·9	1460·7	50·000729	331	150	— 371	50·000839
Mean.....	.....	3.16	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000841
May 1....	4252	10.45	8·40	1892·1	2437·9	1656·3	1463·7	50·000604	411	146	— 262	50·000899
" 1....	3141	10.58	8·46	1956·9	2586·4	1656·4	1463·7	50·000729	475	146	— 516	50·000834
" 1....	4252	11.50	8·59	2147·8	2558·4	1656·3	1463·7	50·000604	310	146	— 255	50·000805
Mean.....	.....	11.11	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000846
May 2....	4252	11.28	7·46	1920·1	2368·9	1663·1	1460·9	50·000604	339	153	— 292	50·000804
" 2....	3141	11·38	7·52	1651·1	2323·6	1663·1	1460·9	50·000729	508	153	— 577	50·000813
" 2....	3141	11.50	7·52	1453·7	2176·3	1663·1	1460·9	50·000729	546	153	— 577	50·000815
Mean.....	.....	11.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000823
May 2....	4252	4.15	7·54	1877·9	2364·5	1663·1	1460·9	50·000604	368	153	— 289	50·000836
" 2....	3141	4.24	7·53	1774·3	2464·8	1663·1	1460·9	50·000729	522	153	— 577	50·000827
Mean.....	.....	4.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000832
May 3....	4252	11.43	6·76	1868·3	2399·2	1663·6	1466·8	50·000604	401	149	— 314	50·000840
" 3....	3141	11.54	6·82	1806·0	2555·8	1663·6	1466·8	50·000729	567	149	— 623	50·000822
Mean.....	.....	11.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000831
May 3....	4252	4.04	7·30	1982·7	2521·8	1663·6	1466·8	50·000604	407	149	— 297	50·000863
" 3....	3141	4.16	7·37	2150·2	2788·5	1663·6	1466·8	50·000729	482	149	— 587	50·000773
Mean.....	.....	4.10	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000818
May 4....	4252	9.48	6·89	1898·5	2370·2	1665·0	1468·0	50·000604	356	149	— 310	50·000799
" 4....	3141	9.59	7·01	1731·8	2455·0	1665·0	1468·0	50·000729	546	149	— 611	50·000813
Mean.....	.....	9.53	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000806
May 4....	4252	3.43	7·93	1867·8	2318·1	1665·0	1468·0	50·000604	340	149	— 277	50·000816
" 4....	3141	3.54	8·02	1708·5	2284·7	1665·0	1468·0	50·000729	435	149	— 545	50·000768
Mean.....	.....	3.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	50·000792

TABLE 6

DETERMINATION OF LENGTH OF TAPE 3140 DEDUCED FROM REFERENCE TAPES 3141 AND 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at C. 16°·5
				Tape		Cut-off			Microm.			
				South	North	South	North		Tape	Cut-off	Temp.	
1917		a.m.	°					Metres	μ	μ	μ	Metres
April 25..	3140	10.50	6·41	1205·9	2429·0	1648·5	1460·5	50·000765	− 924	− 142	651	50·000350
" 25..	3140	3.22	7·64	1579·3	2761·4	1648·5	1460·5	50·000728	− 893	− 142	577	50·000270
" 26..	3140	10.35	5·73	1549·1	2829·8	1645·2	1461·6	50·000760	− 968	− 139	697	50·000350
" 26..	3140	10.50	5·84	1386·4	2666·0	1645·2	1461·6	50·000760	− 967	− 139	690	50·000344
" 26..	3140	2.55	6·09	1823·5	3136·1	1645·2	1461·6	50·000772	− 992	− 139	674	50·000315
" 30..	3140	2.50	10·35	1555·1	2596·7	1658·9	1460·7	50·000844	− 987	− 150	395	50·000302
May 1..	3140	11.15	8·56	1525·9	2737·1	1656·3	1463·7	50·000846	− 915	− 146	510	50·000295
" 2..	3140	4.37	7·47	1296·9	2577·2	1663·1	1460·9	50·000832	− 967	− 153	582	50·000294
" 3..	3140	12.05	6·90	1212·1	2511·6	1663·6	1466·8	50·000830	− 982	− 149	619	50·000318
" 3..	3140	4.25	7·40	1664·3	2558·9	1663·6	1466·8	50·000818	− 978	− 149	586	50·000278
" 4..	3140	10.08	6·98	1254·6	2504·5	1665·0	1468·0	50·000806	− 944	− 149	613	50·000326
" 4..	3140	4.25	7·99	1334·4	2555·6	1665·0	1468·0	50·000792	− 923	− 149	548	50·000268
											Mean	50·000309

TABLE 7

DETERMINATION OF LENGTH OF TAPE 3139 DEDUCED FROM REFERENCE TAPES 3141 AND 4252

Date	Tape	a.m. Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at C. 16°·5
				Tape		Cut-off			Microm.			
				South	North	South	North		Tape	Cut-off	Temp.	
1917			°					Metres	μ	μ	μ	Metres
April 25..	3139	11.15	6·50	1069·1	3059·5	1648·5	1460·5	50·000762	−1504	− 142	640	49·999756
" 25..	3139	3.05	7·60	845·8	2742·5	1648·5	1460·5	50·000727	−1433	− 142	567	49·999719
" 26..	3139	11.23	5·98	900·7	2971·6	1645·2	1461·6	50·000761	−1565	− 139	671	49·999728
" 26..	3139	3.05	6·11	1180·9	3176·1	1645·2	1461·6	50·000773	−1508	− 139	663	49·999789
" 30..	3139	3.05	10·41	884·6	2696·3	1658·9	1460·7	50·000841	−1369	− 150	388	49·999710
May 1..	3139	11.25	8·56	1042·9	2918·8	1656·3	1463·7	50·000846	−1417	− 146	506	49·999789
" 2..	3139	4.50	7·49	833·5	2837·0	1663·1	1460·9	50·000833	−1514	− 153	574	49·999740
" 3..	3139	12.15	6·90	995·2	3013·0	1663·6	1466·8	50·000830	−1525	− 149	613	49·999769
" 3..	3139	4.35	7·37	1096·1	3027·7	1663·6	1466·8	50·000818	−1460	− 149	582	49·999791
" 4..	3139	10.19	7·04	982·4	2943·1	1665·0	1468·0	50·000806	−1482	− 149	604	49·999779
" 4..	3139	4.13	8·01	916·8	2803·4	1665·0	1468·0	50·000792	−1426	− 149	540	49·999757
											Mean	49·999757

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TABLE 8

DETERMINATION OF LENGTH OF TAPE 13814 DEDUCED FROM REFERENCE TAPES 3141 AND 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at C. 16°.05
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		p.m.	°					Metres	μ	μ	μ	Metres
April 26..	13814	3.35	6·15	1772·8	2472·6	1645·2	1461·6	50·000773	— 529	— 139	424	50·000529
May 1...	13814	11.39	8·64	1816·1	2546·2	1656·3	1463·7	50·000846	— 552	— 146	322	50·000470
" 2...	13814	5.02	7·43	1823·5	2620·9	1663·1	1460·9	50·000832	— 603	— 150	372	50·000451
" 3...	13814	4.43	7·37	1790·6	2567·0	1663·6	1466·8	50·000817	— 587	— 149	374	50·000455
" 4...	13814	10.27	7·06	1646·0	2428·1	1665·0	1468·0	50·000806	— 591	— 149	385	50·000451
" 4...	13814	4.25	8·07	1599·4	2348·0	1665·0	1468·0	50·000792	— 566	— 149	346	50·000423
											Mean	50·000463

TABLE 9

DETERMINATION OF LENGTH OF 5-METRE BAR FROM STANDARD NICKEL BAR NO. 10239

LENGTH OF NICKEL BAR=1·0000269 METRES

Date and Time	Microscope	1-metre Bar		5-metre Bar			5 Lengths of 1-metreBar	Corrections			Length of 5-metre Bar.
		South	North S-N	South	North	S-N		bs-bn	Bs - Br	Sector	
1917			μ			μ	Metres	μ	μ	μ	Metres
Sept. 27...	II	1499·8	-1481·4	1504·6		1486·1	5·00001345	117·4	−303·8	1·3	4·9999494
a.m.	V	1503·4	1504·1 ·7								
11.28	III	2327·5	2324·5 — 30·0								
	IV	2295·7	2296·5 ·8								
	V	1888·7	1887·3 — 14·0								
	VI	2122·0	1601·7		2371·3	−1789·9					
	II	1507·5	-1489·0	1502·8		1484·3	5·00001345	112·7	−303·7	1·5	4·9999450
	V	1850·7	1854·4 3·6								
2.50	III	2326·0	2322·5 — 35·0								
	IV	2296·1	2292·0 — 4·0								
	V	1028·9	1030·3 1·4								
	VI	2125·3	1604·2		2368·9	−1788·0					
	VI	2122·1	1601·8		2373·2	−1791·3	5·00001345	119·5	−303·8	1·2	4·9999504
	V	1003·9	1004·7 ·8								
3.45	IV	2298·3	2299·1 ·8								
	III	2321·1	2320·2 — ·9								
	V	1054·6	1052·7 — 1·9								
	II	1499·5	-1481·1	1506·5		1487·5					
Sept. 28...	II	1506·3	-1487·8	1504·1		1485·6	5·00001345	115·3	−295·7	1·7	4·9999558
	V	1077·0	1077·1 ·1								
	III	2334·9	2332·1 — 2·8								
10.00	IV	2303·7	2302·5 — 1·2								
	V	1729·5	1727·9 — 1·6								
	VI	2131·1	1608·6		2360·0	−1781·3					
Sept. 28...	VI	2118·9	1599·3		2355·5	−1778·0	5·00001345	107·4	−290·0	·6	4·9999525
	V	1819·5	1818·5 — 1·0								
	IV	2300·2	2300·2 ·0								
10.52	III	2332·3	2330·3 — 2·0								
	V	1458·2	1457·4 — 8·0								
	II	1506·6	-1488·1	1506·5		1488·0					

TABLE 9—*Concluded*

DETERMINATION OF LENGTH OF 5-METRE BAR FROM STANDARD NICKEL BAR NO. 10239

Date and Time	Microscope	1-metre Bar			5-metre Bar			5 Lengths of 1-metreBar	Corrections			Length of 5-metre Bar.
		South	North	S–N	South	North	S–N		bs-bn	Bs-Br	Sector	
1917				μ			μ	Metres	μ	μ	μ	Metres
Sept. 28...	II	1503·0	.....	-1484·5	1504·7	.....	1486·2	5·00001345	109·0	−289·4	·8	4·9999549
a.m.	V	1454·5	1454·4	− ·1	.....	.....	.....	.....	.....	.....	.....	.....
11.30	III	2324·0	2320·8	− 3·2	.....	.....	.....	.....	.....	.....	.....	.....
	IV	2284·0	2286·8	2·8	.....	.....	.....	.....	.....	.....	.....	.....
	V	1561·3	1561·8	·5	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	2111·2	1593·5	.....	2352·4	−1775·6	.....	.....	.....	.....	.....
	VI	.....	2127·5	1605·8	.....	2373·9	−1791·9	5·00001345	109·4	−295·3	·3	4·9999489
	V	1579·1	1578·7	− ·4	.....	.....	.....	.....	.....	.....	.....	.....
2.25	IV	2308·7	2305·6	− 3·1	.....	.....	.....	.....	.....	.....	.....	.....
	III	2337·7	2338·3	·6	.....	.....	.....	.....	.....	.....	.....	.....
	V	1684·8	1683·3	− 1·5	.....	.....	.....	.....	.....	.....	.....	.....
	II	1509·6	.....	-1492·0	1515·2	.....	1496·6	.....	.....	.....	.....	.....
	II	1520·0	.....	-1501·3	1516·45	.....	1497·7	5·00001345	100·1	−290·5	2·0	4·9999443
	V	1681·2	1678·9	− 23·0	.....	.....	.....	.....	.....	.....	.....	.....
	III	2335·3	2338·0	2·6	.....	.....	.....	.....	.....	.....	.....	.....
	IV	2309·6	2302·8	− 6·7	.....	.....	.....	.....	.....	.....	.....	.....
	V	1280·0	1282·0	2·0	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	2127·5	1605·8	.....	2369·1	−1788·2	.....	.....	.....	.....	.....
Sept. 28...	VI	.....	2129·0	1607·0	.....	2373·0	−1791·1	5·00001345	107·7	−293·3	·8	4·9999497
	V	1742·9	1745·0	2·1	.....	.....	.....	.....	.....	.....	.....	.....
	IV	2302·6	2305·0	2·4	.....	.....	.....	.....	.....	.....	.....	.....
4.00	III	2338·9	2337·9	− 1·0	.....	.....	.....	.....	.....	.....	.....	.....
	V	1586·2	1589·0	2·7	.....	.....	.....	.....	.....	.....	.....	.....
	II	1524·2	.....	-1505·5	1516·5	.....	1497·8	.....	.....	.....	.....	.....
Sept. 29...	II	1503·3	.....	-1485·8	1504·4	.....	1486·9	5·00001345	104·7	−293·3	·8	4·9999467
	V	1568·5	1566·7	− 1·8	.....	.....	.....	.....	.....	.....	.....	.....
9.30	III	2320·0	2321·4	1·4	.....	.....	.....	.....	.....	.....	.....	.....
	IV	2286·5	2287·8	1·3	.....	.....	.....	.....	.....	.....	.....	.....
	V	1508·5	1509·8	1·3	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	2104·2	1588·3	.....	2358·5	−1780·2	.....	.....	.....	.....	.....
	VI	.....	2105·6	1589·3	.....	2358·6	−1780·3	5·00001345	102·4	−294·0	·6	4·9999435
	V	1104·6	1105·5	·9	.....	.....	.....	.....	.....	.....	.....	.....
10.25	IV	2289·4	2288·8	− 6·0	.....	.....	.....	.....	.....	.....	.....	.....
	III	2321·0	2322·5	1·5	.....	.....	.....	.....	.....	.....	.....	.....
	V	1386·8	1383·3	− 3·4	.....	.....	.....	.....	.....	.....	.....	.....
	II	1503·9	.....	-1485·4	1504·7	.....	1486·3	.....	.....	.....	.....	.....
	II	1503·9	.....	-1485·4	1503·0	.....	1484·6	5·00001345	102·4	−290·0	·6	4·9999475
	V	1381·1	1380·7	− ·4	.....	.....	.....	.....	.....	.....	.....	.....
	III	2319·3	2321·7	2·4	.....	.....	.....	.....	.....	.....	.....	.....
	IV	2280·8	2282·3	1·5	.....	.....	.....	.....	.....	.....	.....	.....
	V	1805·8	1803·2	− 2·5	.....	.....	.....	.....	.....	.....	.....	.....
	VI	.....	2102·3	1586·8	.....	2351·1	−1774·6	.....	.....	.....	.....	.....
											Mean	4·9999499

TABLE 10.

LENGTH OF COMPARATOR FROM 5-METRE BAR.

Date	Time	Microm. Readings				10 Lgths. of 5-metre Bar.	Microm. Corrections		Length of Comparator
		Bar		Cut-off			Bar	Cut-off	
		South	North	South	North				
1917.	p.m.					Metres	μ	μ	Metres
Sept. 21	3.37	548·0	2800·0	1664·5	1366·5	49·999499	1702	220	50·001421
	4.03	548·0	2759·0	1664·5	1366·5	49·999499	1678	220	50·001392
								Mean	50·001407
" 22	2.04	692·0	2800·0	1663·9	1368·0	49·999499	1593	226	50·001318
	2.38	692·0	2792·5	1663·9	1368·0	49·999499	1587	226	50·001312
								Mean	50·001315
" 22	3.37	673·0	2800·0	1663·9	1368·0	49·999499	1607	226	50·001332
	4.02	673·0	2795·5	1663·9	1368·0	49·999499	1604	226	50·001329
								Mean	50·001331
" 24	1.58	897·5	2800·0	1686·1	1370·5	49·999499	1438	241	50·001178
	2.38	897·5	2791·0	1686·1	1370·5	49·999499	1430	241	50·001170
								Mean	50·001174
" 24	3.46	835·6	2800·0	1686·1	1370·5	49·999499	1484	241	50·001224
	4.11	835·6	2798·0	1686·1	1370·5	49·999499	1482	241	50·001222
								Mean	50·001223
" 25	1.42	796·5	2800·0	1676·7	1371·9	49·999499	1514	233	50·001246
	2.05	796·5	2756·5	1676·7	1371·9	49·999499	1488	233	50·001213
								Mean	50·001229
" 25	3.21	804·5	2800·0	1676·7	1371·9	49·999499	1508	233	50·001240
	3.42	804·5	2790·5	1676·7	1371·9	49·999499	1509	233	50·001233
								Mean	50·001236

TABLE 11

DETERMINATION OF LENGTH OF TAPE 4252 FROM 5-METRE BAR.

Date	Tape	Time	Temp.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.			
			C.	South	North	South	North		Tape	Cut-off	Temp.	
1917		p.m.	°					Metres	μ	μ	μ	Metres
Sept. 21	4252	4.42	16·57	1539·3	2325·9	1664.6	1366·5	50·001407	− 594	− 220	− 2	50·000591
" 21	4252	4.51	16·57	1391·7	2240·8	.....	.....	50·001407	− 642	− 220	− 2	50·000543
" 21	4252	4.58	16·56	1769·5	2581·9	.....	.....	50·001407	− 614	− 220	− 2	50·000571
" 21	4252	5.05	16·56	1604·9	2373·0	.....	.....	50·001407	− 580	− 220	− 2	50·000605
											Mean	50·000578
Sept. 22	4252	1.26	15·03	1063·4	1876·0	1663·9	1368·0	50·001323	− 614	− 226	47	50·000531
" 22	4252	1.32	15·15	1066·8	1813·5	.....	.....	50·001323	− 564	− 226	43	50·000576
" 22	4252	3.11	15·20	1823·3	2615·3	.....	.....	50·001323	− 598	− 226	42	50·000541
" 22	4252	3.18	15·18	1645·4	2441·8	.....	.....	50·001323	− 602	− 226	42	50·000537
" 22	4252	4.36	15·16	1906·7	2679·4	.....	.....	50·001323	− 584	− 226	43	50·000556
" 22	4252	4.42	15·15	1613·1	2420·1	.....	.....	50·001323	− 610	− 226	43	50·000530
											Mean	50·000545
Sept. 24	4252	1.27	14·23	1916·7	2569·1	1686·1	1370·5	50·001198	− 493	− 241	73	50·000537
" 24	4252	1.32	14·23	2064·5	2703·0	.....	.....	50·001198	− 482	− 241	73	50·000548
" 24	4252	3.12	14·64	1365·6	2011·4	.....	.....	50·001198	− 488	− 241	60	50·000529
" 24	4252	3.18	14·64	1571·4	2214·6	.....	.....	50·001198	− 486	− 241	60	50·000531
" 24	4252	4.35	14·76	1584·6	2231·3	.....	.....	50·001198	− 489	− 241	56	50·000524
" 24	4252	4.42	14·76	1521·2	2179·7	.....	.....	50·001198	− 498	− 241	56	50·000515
											Mean	50·000531
Sept. 25	4252	2.36	14·46	1443·8	1985·9	1676·7	1371·9	50·001232	− 440	− 233	65	50·000624
" 25	4252	2.41	14·46	1778·8	2376·2	.....	.....	50·001232	− 451	− 233	65	50·000613
" 25	4252	2.46	14·46	1840·6	2421·1	.....	.....	50·001232	− 439	− 233	65	50·000625
" 25	4252	2.50	14·46	1664·7	2237·3	.....	.....	50·001232	− 433	− 233	65	50·000631
" 25	4252	2.56	14·46	1760·4	2347·5	.....	.....	50·001232	− 444	− 233	65	50·000620
" 25	4252	3.01	14·46	1946·6	2533·8	.....	.....	50·001232	− 444	− 233	65	50·000628
											Mean	50·000622
Mean determination of tape 4252												50·000569

TABLE 12

DEDUCED LENGTH OF COMPARATOR FROM REFERENCE TAPE 4252

Date	Reference Tape	Time	Temp. C.	Microm. Readings				Length of Tape at 16°·5 C.	Corrections			Length of Comparator
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Sept. 21..	4252	10.36	16·05	1548·6	2371·5	1671·4	1303·7	50·000569	622	232	− 14	50·001409
" 21..	4252	11.37	16·20	1776·4	2371·5	.....	.....	50·000569	612	232	− 10	50·001403
											Mean	50·001406
Sept. 22..	4252	10.28	14·67	1725·3	2514·8	1674·8	1373·2	50·000569	597	228	− 59	50·001335
" 22..	4252	11.22	14·84	1985·4	2796·6	.....	.....	50·000569	613	228	− 53	50·001357
" 22..	4252	11.58	14·89	1326·0	2157·3	.....	.....	50·000569	627	228	− 52	50·001372
											Mean	50·001355
Sept. 24..	4252	9.16	13·14	1726·4	2459·4	1683·3	1372·0	50·000569	554	235	− 108	50·001250
" 24..	4252	10.47	13·45	1819·7	2471·4	.....	.....	50·000569	492	235	− 98	50·001198
" 24..	4252	11.25	13·59	1798·5	2521·6	.....	.....	50·000569	554	235	− 93	50·001265
" 24..	4252	12.02	13·83	1668·7	2284·7	.....	.....	50·000569	465	235	− 85	50·001184
											Mean	50·001224
Sept. 25..	4252	9.05	13·30	1718·6	2396·2	1686·7	1373·3	50·000569	512	237	− 102	50·001216
" 25..	4252	9.51	13·49	1496·2	2178·5	.....	.....	50·000569	516	237	− 96	50·001226
" 25..	4252	10.50	13·68	1672·6	2372·1	.....	.....	50·000569	528	237	− 90	50·001244
" 25..	4252	11.29	13·84	1586·0	2222·0	.....	.....	50·000569	481	237	− 85	50·001202
											Mean	50·001222

TABLE 13

DETERMINATION OF LENGTH OF TAPE 3141 DEDUCED FROM REFERENCE TAPE 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Sept. 21..	3141	10.57	16·13	1612·6	2425·0	1671·4	1363·7	50·001406	− 613	− 232	23	50·000584
" 21..	3141	11.55	16·24	1716·6	2490·2	.....	.....	50·001406	− 584	− 232	17	50·000597
Sept. 22..	3141	10.38	14·69	1828·9	2643·6	1674·8	1373·2	50·001355	− 616	− 228	115	50·000626
" 22..	3141	11.32	14·81	2089·0	2848·9	.....	.....	50·001355	− 574	− 228	107	50·000660
Sept. 24..	3141	9.35	13·25	1944·8	2701·8	1683·2	1372 0	50·001224	− 572	− 235	206	50·000623
" 24..	3141	10.53	13·51	1387·7	2172·6	.....	.....	50·001224	− 593	− 235	190	50·000586
" 24..	3141	11.32	13·61	1785·1	2458·3	.....	.....	50·001224	− 509	− 235	184	50·000664
Sept. 25..	3141	9.13	13·34	1708·4	2474·0	1686·7	1373·3	50·001222	− 578	− 237	201	50·000608
" 25..	3141	10.21	13·54	1788·7	2500·3	.....	.....	50·001222	− 538	− 237	188	50·000635
" 25..	3141	11.00	13·71	1578·7	2337·6	.....	.....	50·001222	− 573	− 237	177	50·000589
											Mean	50·000617

TABLE 14

DETERMINATION OF LENGTH OF TAPE 3140 DEDUCED FROM REFERENCE TAPE 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Sept. 21..	3140	11.12	16·04	1083·1	2406·3	1671·4	1363·7	50·001406	−1000	− 232	29	50·000203
Sept. 22..	3140	10.49	14·73	1198·4	2603·2	1674·8	1373·2	50·001355	−1061	− 228	112	50·000178
" 22..	3140	11.40	14·84	1495·4	2854·5	.....	.....	50·001355	−1027	− 228	105	50·000205
Sept. 24..	3140	10.18	13·44	1331·2	2879·9	1683·2	1372·0	50·001224	−1019	− 235	194	50·000164
" 24..	3140	11.00	13·54	1479·4	2696·7	.....	.....	50·001224	− 927	− 235	188	50·000250
" 24..	3140	11·40	13·63	1002·1	2326·0	.....	.....	50·001224	−1000	− 235	182	50·000171
Sept. 25..	3140	9.21	13·38	1124·1	2400·8	1686·7	1373·3	50·001222	− 965	− 237	198	50·000218
" 25..	3140	10.28	13·59	923·7	2200·7	.....	.....	50·001222	− 965	− 237	185	50·000205
" 25..	3140	11.07	13·75	1692·5	2928·1	.....	.....	50·001222	− 930	− 237	175	50·000230
											Mean	50·000203

TABLE 15

DETERMINATION OF LENGTH OF TAPE 3139 DEDUCED FROM REFERENCE TAPE 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Sept. 21..	3139	10.26	16·20	836·6	2324·6	1671·4	1363·7	50·001406	−1491	− 232	19	49·999702
Sept. 22..	3139	10.58	14·70	883·8	3047·5	1674·8	1373·2	50·001355	−1635	− 228	113	49·999605
" 22..	3139	11.48	14·99	924·3	2925·8	.....	.....	50·001355	−1512	− 228	95	49·999710
Sept. 24..	3139	10.28	13·42	1023·1	2989·5	1683·2	1372·0	50·001224	−1482	− 235	194	49·999701
" 24..	3139	11.08	13·56	1019·5	2927·9	.....	.....	50·001224	−1442	− 235	185	49·999732
" 24..	3139	11.48	13·66	1059·8	3003·7	.....	.....	50·001224	−1469	− 235	179	49·999699
Sept. 25..	3139	9.29	13·43	782·4	2715·5	1686·7	1373·3	50·001222	−1468	− 237	193	49·999710
" 25..	3139	10.38	13·62	957·8	3015·9	.....	.....	50·001222	9 1555	− 237	181	49·999611
" 25..	3139	11.14	13·78	901·8	2876·2	.....	.....	50·001222	−1492	− 237	171	49·999664
											Mean	49·999682

TABLE 16

DETERMINATION OF LENGTH OF TAPE 13814 DEDUCED FROM REFERENCE TAPE 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Sept. 24..	13814	10.38	13·39	1717·3	2605·5	1683·2	1372·0	50·001224	− 739	− 235	131	50·000381
" 24..	13814	11.13	13·57	1454·3	2431·8	.....	.....	50·001224	− 738	− 235	123	50·000374
" 24..	13814	11.55	13·74	1438·4	2355·7	.....	.....	50·001224	− 693	− 235	116	50·000412
Sept. 25..	13814	9.38	13·46	1342·0	2264·3	1686·7	1373·3	50·001222	− 697	− 237	128	50·000416
" 25..	13814	10.44	13·65	1792·1	2742·3	.....	.....	50·001222	− 718	− 237	120	50·000387
" 25..	13814	11.22	13·81	1276·1	2202·3	.....	.....	50·001222	− 709	− 237	113	50·000396
											Mean	50·000394

TABLE 17

LENGTH OF COMPARATOR FROM 5-METRE BAR

Date	Time	Microm. Readings				10 Lengths of 5-metre Bar	Correction Microm.		Length of Comparator
		5-metre Bar		Cut-off			Bar	Cut-off	
		South	North	South	North				
1917	a.m.					Metres	μ	μ	Metres
Nov. 2	10.15	800·0	2330·0	1695·5	1348·9	49·999499	1156	262	50·000917
" 2	10.53	814·5	2330·0	.....	.....	49·999499	1145	262	50·000906
								Mean	50·000912
Nov. 2	2.00	800·0	2298·0	1682·8	1348·9	49·999499	1132	252	50·000883
" 2	3.25	762·5	2298·0	.....	.....	49·999499	1160	252	50·000911
								Mean	50·000897
Nov. 3	9.30	800·0	2329·0	1680·5	1344·8	49·999499	1155	254	50·000908
" 3	10.40	802·0	2329·0	.....	.....	49·999499	1154	254	50·000907
								Mean	50·000907

TABLE 18

DETERMINATION OF LENGTH OF TAPE 4252 FROM 5-METRE BAR

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.		Temp	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Nov. 2	4252	10.57	5·30	1245·2	1826·0	1695·5	1348·9	50·000912	−439	−262	363	50·000574
" 2	4252	11.04	5·32	1584·8	2183·2	.....	.....	50·000912	−452	−262	363	50·000561
" 2	4252	11.08	5·33	1715·7	2261·2	.....	.....	50·000912	−412	−262	362	50·000600
" 2	4252	11.13	5·35	1779·3	2382·6	.....	.....	50·000912	−456	−262	362	50·000556
" 2	4252	11.16	5·37	1813·0	2399·2	.....	.....	50·000912	−443	−262	361	50·000568
" 2	4252	11.20	5·39	1786·6	2386·7	.....	.....	50·000912	−453	−262	361	50·000558
											Mean.	50·000569
" 2	4252	2.40	5·51	1477·6	2070·1	1682·4	1348·9	50·000897	−448	−252	357	50·000554
" 2	4252	2.48	5·51	1589·0	2128·0	.....	.....	50·000897	−407	−252	357	50·000595
" 2	4252	2.52	5·51	1738·3	2279·1	.....	.....	50·000897	−409	−252	357	50·000593
" 2	4252	2.58	5·51	1675·3	2285·0	.....	.....	50·000897	−415	−252	357	50·000587
" 2	4252	3.05	5·51	1646·1	2213·4	1682·4	1348·9	50·000897	−429	−252	357	50·000573
" 2	4252	3.13	5·51	1647·2	2207·9	.....	.....	50·000897	−403	−252	357	50·000599
											Mean.	50·000583
Mar. 3	4252	9.55	5·31	1439·2	2007·8	1680·5	1344·8	50·000908	−430	−254	363	50·000587
" 3	4252	10.00	5·31	1584·3	2136·2	.....	.....	50·000908	−417	−254	363	50·000600
" 3	4252	10.04	5·31	1614·5	2199·6	.....	.....	50·000908	−442	−254	363	50·000575
" 3	4252	10.10	5·31	1662·0	2227·0	.....	.....	50·000908	−427	−254	363	50·000590
" 3	4252	10.14	5·31	1606·3	2144·6	.....	.....	50·000908	−445	−254	363	50·000572
" 3	4252	10.20	5·31	1680·3	2237·5	.....	.....	50·000908	−421	−254	363	50·000596
											Mean	50·000587
Mean determination of tape 4252												50·000580

TABLE 19.

DEDUCED LENGTH OF COMPARATOR FROM REFERENCE TAPE 4252

Date	Reference Tape	Time	Temp.	Microm. Readings				Length of Tape at 16°·5 C.	Corrections			Length of Comparator
				Tape		Cut-off			Microm.			
				South	North	South	North		Tape	Cut-off	Temp.	
1917		a.m.	C.					Metres	μ	μ	μ	Metres
Nov. 5...	4252	9.22	3·93	1475·4	2101·2	1689·3	1341·7	50·000580	473	263	− 408	50·000908
" 5...	4252	10.16	4·04	1897·9	2468·3	.....	.....	50·000580	431	263	− 404	50·000870
" 5...	4252	11.09	4·23	1472·2	2048·8	.....	.....	50·000580	436	263	− 398	50·000881
" 5...	4252	11.45	4·43	1913·2	2421·5	.....	.....	50·000580	384	263	− 392	50·000835
											Mean	50·000898
Nov. 5...	4252	2.14	4·60	1045·1	1640·8	1696·7	1340·0	50·000580	450	270	− 386	50·000914
" 5...	4252	2.54	4·69	2017·9	2582·3	.....	.....	50·000580	426	270	− 383	50·000893
" 5...	4252	3.30	4·71	1763·3	2267·9	.....	.....	50·000580	381	270	− 383	50·000848
" 5...	4252	4.05	4·67	1979·0	2500·9	.....	.....	50·000580	394	270	− 384	50·000860
											Mean	50·000879
Nov. 6...	4252	9.20	3·63	1326·7	1897·9	1701·6	1344·8	50·000580	432	270	− 420	50·000852
" 6...	4252	10.00	3·81	1340·9	1865·7	.....	.....	50·000580	397	270	− 412	50·000835
" 6...	4252	10.35	3·81	1684·2	2248·6	.....	.....	50·000580	426	270	− 412	50·000864
" 6...	4252	11.11	3·80	1421·4	1990·9	.....	.....	50·000580	430	270	− 412	50·000868
											Mean	50·000855
Nov. 6...	4252	1.32	3·91	1386·0	1954·4	1697·8	1349·4	50·000580	429	263	− 409	50·000863
" 6...	4252	2.10	4·15	1813·7	2411·2	.....	.....	50·000580	451	263	− 401	50·000893
" 6...	4252	2.47	4·10	1374·0	1931·6	.....	.....	50·000580	421	263	− 402	50·000862
" 6...	4252	3.27	4·08	1945·3	2473·0	.....	.....	50·000580	399	263	− 403	50·000839
											Mean	50·000864

TABLE 20

DETERMINATION OF LENGTH OF TAPE 3141 DEDUCED FROM REFERENCE TAPE 4252.

Date	Tape	Time	Temp.	Microm. Readings				Length of Comparators	Corrections			Length of Tape at 16°·5 C.
				Tape		Cut-off			Microm.			
				South	North	South	Notrh		Tape	Cut-off	Temp.	
1917		a.m.	C.					Metres	μ	μ	μ	Metres
Nov. 5...	3141	9.30	3·93	1200·3	2233·2	1689·3	1341·7	50·000898	− 855	− 263	813	50·000593
" 5...	3141	10.39	4·13	1219·2	2388·3	.....	.....	50·000898	− 883	− 263	800	50·000552
" 5...	3141	11.19	4·27	1635·2	2701·2	.....	.....	50·000898	− 805	− 263	790	50·000620
											Mean	50·000588
" 5...	3141	2.20	4·62	1583·1	2672·4	1696·7	1340·0	50·000879	− 823	− 270	767	50·000553
" 5...	3141	3.00	4·69	1494·8	2487·8	.....	.....	50·000879	− 750	− 270	763	50·000622
" 5...	3141	3.35	4·70	1782·3	2835·6	.....	.....	50·000879	− 796	− 270	762	50·000575
											Mean	50·000583
Nov. 6...	3141	9.29	3·67	1815·0	2886·8	1701·6	1344·7	50·000855	− 810	− 270	831	50·000606
" 6...	3141	10.08	3·81	1044·5	2134·3	.....	.....	50·000855	− 823	− 270	821	50·000593
" 6...	3141	10.45	3·81	1564·9	2625·9	.....	.....	50·000855	− 802	− 270	821	50·000562
											Mean	50·000587
" 6...	3141	1.40	3·95	1474·3	2512·9	1697·7	1349·4					
" 6...	3141	2.18	4·14	1499·3	2548·1	.....	.....	50·000864	− 785	− 263	812	50·000628
" 6...	3141	2.54	4·10	1649·0	2666·2	.....	.....	50·000864	− 792	− 263	800	50·000609
								50·000864	− 769	− 263	802	50·000634
											Mean	50·000624
Mean determination of tape 3141.....								.....	.....	.....	.....	50·000596

TABLE 21

DETERMINATION OF LENGTH OF TAPE 3140 FROM REFERENCE TAPE 4252.

Date	Tape	Time	Temp.	Microm. Readings. Tape South	Tape North	Cut-off South	Cut-off North	Length of Comparators	Corrections Microm. Tape	Microm. Cut-off	Temp.	Length of Tape at 16°·5 C.
1917		a.m.	°					Metres	μ	μ	μ	Metres
Nov. 5...	3140	9.39	3·93	719·5	2373·0	1689·3	1341·7	50·000898	−1242	− 263	816	50·000209
" 5...	3140	19.45	4·15	1185·8	2722·7	.....	.....	50·000898	−1161	− 263	802	50·000276
" 5...	3140	11.25	4·31	1329·4	2866·9	.....	.....	50·000898	−1162	− 263	791	50·000264
											Mean	50·000250
" 5...	3140	2.27	4·64	946·6	2530·9	1696·7	1340·0	50·000879	−1197	− 270	766	50·000178
" 5...	3140	3.05	4·70	1275·6	2803·9	.....	.....	50·000879	−1155	− 270	762	50·000216
"	3140	3.42	4·69	1170·7	2711·0	.....	.....	50·000879	−1164	− 270	763	50·000208
											Mean	50·000201
Nov. 6...	3140	9.38	3·70	1408·7	2816·5	1701·6	1344·7	50·000855	−1253	− 270	832	50·000164
" 5...	3140	10.14	3·81	1241·0	2847·7	.....	.....	50·000855	−1214	− 270	825	50·000196
" 5...	3140	10.50	3·81	972·0	2553·0	.....	.....	50·000855	−1195	− 270	825	50·000215
											Mean	50·000192
" 6...	3140	1.49	4·00	1138·8	2659·2	1697·7	1349·4	50·000864	−1149	− 263	811	50·000263
" 6...	3140	2.27	4·13	1283·2	2837·6	.....	.....	50·000864	−1175	− 263	803	50·000229
" 6...	3140	3.02	4·9	1101·4	2651·9	.....	.....	50·000864	−1172	− 263	805	50·000234
											Mean	50·000242
Mean determination of tape 3140												50·000221

TABLE 22

LENGTH OF TAPE 3139 DEDUCED FROM REFERENCE TAPE 4252

Date	Tape	Time	Temp. C.	Microm. Readings Tape South	Tape North	Cut-off South	Cut-off North	Length of Comparator	Corrections Microm. Tape	Microm. Cut-off	Temp.	Length of Tape at 16°·5 C.
1917		a.m.	°					Metres	μ	μ	μ	Metres
Nov. 5...	3139	9.46	3·94	477·0	2847·1	1689·3	1341·7	50·000898	−1791	− 263	808	49·999652
" 5...	3139	10.54	4·17	446·1	2815·3	.....	.....	50·000898	−1790	− 263	793	49·999638
" 5...	3139	11.32	4·35	526·5	2832·5	.....	.....	50·000898	−1742	− 263	781	49·999674
											Mean	49·999655
Nov. 5...	3139	2.35	4·65	597·8	2881·9	1696·7	1340·0	50·000879	−1726	− 270	761	49·999644
" 5...	3139	3.12	4·70	699·4	2977·3	.....	.....	50·000879	−1721	− 270	758	49·999646
" 5...	3139	3.48	4·68	850·0	3160·8	.....	.....	50·000879	−1746	− 270	759	49·999622
											Mean	49·999637
Nov. 6...	3139	9.45	3·74	707·2	3050·3	1701·6	1344·7	50·000855	−1770	− 270	820	49·999635
" 6...	3139	10.20	3·81	614·8	2986·1	.....	.....	50·000855	−1792	− 270	824	49·999617
" 6...	3139	10.58	3·80	570·6	2899·9	.....	.....	50·000855	−1760	− 270	823	49·999648
											Mean	49·999633
Nov. 6...	3139	1.56	4·05	693·6	2982·0	1697·7	1349·4	50·000864	−1729	− 263	799	49·999671
" 6...	3139	2.33	4·12	636·8	2870·2	.....	.....	50·000864	−1763	− 263	795	49·999633
" 6...	3139	3.10	4·09	647·6	2998·7	.....	.....	50·000864	−1776	− 263	797	49·999622
											Mean	49·999642
Mean determination of tape 3139												49·999642

TABLE 23

LENGTH OF TAPE 13814 DEDUCED FROM REFERENCE TAPE 4252

Date	Tape	Time	Temp. C.	Microm. Readings				Length of Comparator	Corrections			Length of Tape at 16°·5. C.
				Tape		Cut-off			Microm.		Temp.	
				South	North	South	North		Tape	Cut-off		
1917		a.m.	°					Metres	μ	μ	μ	Metres
Nov. 5...	13814	10.03	3·94	1279·3	2182·3	1689·3	1341·7	50·000898	— 682	— 263	528	50·000481
" 5...	13814	11.02	4·20	1755·2	2650·1	.....	.....	50·000898	— 676	— 263	517	50·000476
" 5...	13814	11.39	4·39	1436·4	2282·9	.....	.....	50·000898	— 640	— 263	509	50·000504
											Mean	50·000487
		p.m.										
Nov. 5...	13814	2.40	4·67	1425·6	2323·4	1696·7	1340·0	50·000879	— 678	— 270	497	50·000428
" 5...	13814	3.20	4·71	2138·9	3000·6	.....	.....	50·000879	— 650	— 270	495	50·000454
" 5...	13814	3.55	4·67	1576·9	2432·1	.....	.....	50·000879	— 645	— 270	497	50·000461
											Mean	50·000448
		a.m.										
Nov. 6...	13814	9.52	3·78	1325·9	2236·2	1701·6	1344·7	50·000855	— 688	— 270	534	50·000431
" 6...	13814	10.27	3·81	1687·6	2556·0	.....	.....	50·000855	— 656	— 270	533	50·000462
" 6...	13814	11.03	3·80	1145·6	2035·8	.....	.....	50·000855	— 673	— 270	533	50·000445
											Mean	50·000446
		p.m.										
Nov. 6...	13814	2.04	4·10	1439·3	2295·1	1697·7	1349·4	50·000864	— 647	— 263	521	50·000475
" 6...	13814	2.40	4·11	1779·7	2634·0	.....	.....	50·000864	— 646	— 263	520	50·000475
" 6...	13814	3.20	4·09	1250·4	2098·6	.....	.....	50·000864	— 641	— 263	521	50·000481
											Mean	50·000477
Mean determination of tape 13814												50·000464

TABLE 24

LENGTH OF 5-METRE BAR AT 0° C. AND TAPES AT 16°·5 C. FROM STANDARD NICKEL BAR 10239

Date	5-metre Bar	Tape 4252	Tape 3139	Tape 3140	Tape 3141	Tape 13814
	Metres	Metres	Metres	Metres	Metres	Metres
1908.....	4·9999464					
July, 1914.....	4·9999503	50·000382	49·999525	50·000004	50·000510	50·000067
Dec., 1914.....	4·9999489	50·000415	49·999593	50·000119	50·000600	50·000118
June, 1915.....	4·9999507	50·000446	49·999612	50·000154	50·000615	50·000231
Nov., 1915.....	4·9999432	50·000393	49·999612	50·000142	50·000579	50·000211
May, 1917.....	4·9999490	50·000604	49·999757	50·000309	50·000729	50·000463
Sept., 1917.....	4·9999499	50·000569	49·999682	50·000203	50·000617	50·000394
Nov., 1917.....	.....	50·000580	49·999642	50·000221	50·000596	50·000464

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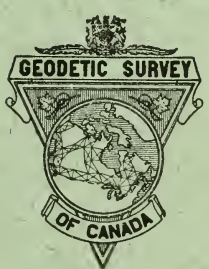
PRECISE LEVELLING

CERTAIN LINES IN ONTARIO and QUEBEC

WITH INDEX AND MAP SHOWING ALL WORK PREVIOUSLY PUBLISHED

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By

F. B. REID, Supervisor of Levelling

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CONTENTS

	Page.
Introduction	5
Description of Bench-Marks:—	
Montreal to Hull, Que	7
St. Martin Junction to Three Rivers, Que	9
Grenville, Que., to Prescott, Ont	10
Ivanhoe to Toronto, Ont	13
Bethany to Port Hope, Ont	15
Myrtle to Whitby, Ont	16
North Toronto to Mimico, Ont	16
Elevations, Table of	18
Rail Elevations	25
Index	29
Map	43

Dir. g. Vol. 4 cont.
6 Aug 21

INTRODUCTION.

This publication contains the results of Precise Levelling by the Geodetic Survey of Canada for certain lines in the provinces of Ontario and Quebec. Precise levelling results previously issued to the public are contained in six "Publications of the Dominion Observatory", as follows:—

Vol. I, No. 2, issued 1912*	Vol. II, No. 1, issued 1915
Vol. I, No. 3, " 1913	Vol. III, No. 6, " 1916
Vol. I, No. 8, " 1914	Vol. III, No. 8, " 1917

and in Publication No. 1 of the Geodetic Survey of Canada. All the above publications are now in the charge of the Superintendent of the Geodetic Survey and may be had upon application to him.

The present work is arranged in the same general form as the previous ones, with the results of the levelling set forth in three tables. The index and map included herein are complete for all the levelling previously published, as well as that in the present publication; the index indicates in which publication descriptions and elevations of bench-marks previously published may be found.

Table I indicates the routes followed between terminal points and gives complete descriptions of all bench-marks established along these routes.

Table II shows in the first two columns the numbers of the bench-marks; in the third and fourth columns the approximate distance (in miles) between bench-marks, and from the initial bench-mark of the line; the fifth and sixth columns (headed "Discrepancy") give the difference (in feet) between the forward levelling and the backward levelling for each section between bench-marks and the accumulated difference from the initial bench-mark. The seventh column gives the elevations of the bench-marks shown in the second column; for convenience, these bench-marks are repeated (in the eighth column) in order that the number of any bench-mark and its elevation may be in adjoining columns. In this table are shown also the elevations determined by the Geodetic Survey of Canada for certain bench-marks established by other surveys and connected with the former.

Table III shows the elevations at railway stations and at crossings of intersecting railways; also on the bridges over rivers and lakes and the more important streams. Rail elevations were in all cases taken on top of the rail, in front of the telegraph office at telegraph stations and opposite the shelter or platform at flag-stations.

The results are given for the following lines:—

1. Montreal to Hull, Que.
2. St. Martin Junction to Three Rivers, Que.
3. Grenville, Que., to Prescott, Ont.
4. Ivanhoe to Toronto, Ont.
5. Bethany to Port Hope, Ont.
6. Myrtle to Whitby, Ont.
7. North Toronto to Mimico, Ont.

Line 1 starts from one of the bench-marks on the Montreal loop-line (last year's publication) and terminates at a previously established bench-mark at Hull; the closing error of the circuit formed by the two lines from Rouse Point to Hull is 0·250 foot—the difference between the two observed elevations for the junction bench-mark at Hull. In the table of elevations given herewith this closing error has been distributed uniformly along the line between St. Martin Junction and Hull at the rate of a little more than ·002 foot per mile.

*Levelling in Yukon Territory only.

Lines 2 and 3 are branches from line 1. Line 3 closes on the original Rouse Point-Toronto line at Prescott, having already intersected the same line at St. Polycarpe Junction and the Finch-Cornwall line at Cornwall. The three links thus formed have been fitted in with the old levelling so as to eliminate the discrepancies at the junction bench-marks.

Line 4 completes the Kempton-Toronto line, the results for which, as far west as Ivanhoe, were published in 1917. Lines 5 and 6 form connections between this and the earlier levelling along the north shore of lake Ontario. Line 7 is a short line running through the suburbs of the city of Toronto; taken in conjunction with the adjacent levelling done several years previously it completes a loop around the western and northwestern portions of the city. The closing errors of lines 4, 5, 6 and 7 have all been disposed of by distributing them as in line 1.

The policy of dispersing the closing errors or fitting the new levelling to the old has been adopted for this year's lines by reason of the fact that all the lines (with the exception of No. 2) form connections between levels which were previously well established and had been published. A proper accordance between all the bench-marks cannot be had until an adjustment is made of the entire net in eastern Canada, but the levelling has now reached a stage where it seems better—pending an adjustment— to eliminate the closing errors and avoid discordant elevations of junction bench-marks with the resulting inconvenience to engineering projects, it being reasonably certain that such closing errors are caused by the ordinary accidental and systematic errors in the levelling and not by any gross errors.

In Table II the observed elevation of each junction bench-mark has been shown, as a matter of interest, as well as the adopted elevation.

The standard bench-mark consists of a copper bolt, three quarters of an inch in diameter and four inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench-Mark). The bolt is sunk horizontally in rock or masonry so that only the circular end is visible; the number of the bench-mark is stamped on this end as well as the letters mentioned above, and a horizontal chisel line is cut, upon which the elevation is taken. At certain points concrete bench-mark piers have been built; these project from six inches to one foot above the ground and extend below the frost line; in all piers built previous to 1917 the copper bolt upon which the elevation was taken was placed horizontally in a side of the pier, about nine inches below the top. In 1917 a new design was adopted, the bolt being placed vertically in the top of the pier. The description indicates in each case the position of the bolt.

TABLE I

BENCH-MARKS BETWEEN MONTREAL (MILE END) AND HULL, QUE., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 18.

Note.—These descriptions are written with the assumption that the railway runs in a north-westerly direction from Mile End to Ste. Thérèse, and thence westerly to a point about 2½ miles from Hull.

826 In square concrete culvert under Canadian Pacific railway, 1¼ miles northwest of Mile End station and 1,600 feet northwest of north line of Baby street, Montreal. Southeast end of northeast face of culvert.

827 In square concrete culvert under Grand Trunk railway, immediately south of junction with Canadian Pacific railway at Jacques Cartier Junction and at mileage 8·4 from Montreal (Place Viger station). North end of east face of culvert.

828 In long steel truss bridge over rivière-des-Prairies, between Bordeaux and Laval Rapides, on Canadian Pacific railway. South retaining wall, southeast end of southwest face, fourth course of stonework below top.

829 In concrete footing of semaphore beside Quebec line of Canadian Pacific railway, about 800 feet northeast of station house at St. Martin Junction. West face of footing (facing Montreal-Hull track), 10 inches below top.

830 In top of concrete bench-mark pier, 2¼ miles northwest of St. Martin Junction, 200 feet southeast of mile post 15 from Montreal and 8 feet northeast of southwest line of Canadian Pacific railway right of way. Also 335 feet southeast of a pair of battery boxes connected with electric block system.

831 In Canadian Pacific railway bridge over rivière-des-Milles Iles, ¼ mile northwest of Ste. Rose and at mileage 17·4 from Montreal. South retaining wall, southwest face, second course of stonework below top.

832 In Roman Catholic church at Ste. Thérèse. Front (or west) wall, first course of stonework below water table course, 18 inches from southwest corner of building.

833 In square stone and concrete culvert under Canadian Pacific railway, 3 miles west of Ste. Thérèse and at second telegraph pole east of mile post 23 from Montreal. East end of north face of culvert.

834 In square stone and concrete culvert under Canadian Pacific railway, 1¾ miles east of St. Augustin and at mileage 25·6 from Montreal. East end of north face of culvert, third course of stonework below top.

835 In square stone and concrete culvert under Canadian Pacific railway, 1¼ miles west of St. Augustin and at mileage 28·7 from Montreal—250 feet east of St. Augustin west mile board. South face of culvert, immediately west of water-passage.

835-A In plate girder bridge immediately west of Ste. Scholastique station, on Canadian Pacific railway. Concrete retaining wall behind west abutment, north end of east face, 32 inches above bridge seat.

836 In Roman Catholic church at Ste. Scholastique. Front (or south) wall, third course of stonework above water table course, 10 feet from southeast corner of building.

837 In top of concrete bench-mark pier, 1¾ miles west of St. Hermas, 6 feet south of north line of Canadian Pacific railway right of way and between third and fourth telegraph poles west of mile post 39 from Montreal—100 feet east of a farm crossing.

838 In Lachute post office. East (side) wall, first course of stonework below water table course, directly above first basement window from rear of building.

839 Destroyed.

840 In west face of small boulder, 1¾ miles west of Staynerville, 10 feet north of south line of Canadian Pacific railway right of way and at eleventh telegraph pole west of mile post 50 from Montreal —150 feet east of west end of first curve west of Staynerville.

841 In square stone (double) culvert under Canadian Pacific railway, 450 feet east of road crossing at Magnesite and at mileage 54·7 from Montreal. West end of south face of coping on south end of culvert.

842 In plate girder bridge on Canadian Pacific railway, ¾ mile east of Grenville. Concrete retaining wall behind east stone abutment, north end of west face, 16 inches above bridge seat.

843 In concrete arch culvert under Canadian Pacific railway, ½ mile east of Grenville and at mileage 57·15 from Montreal. West end of south face of culvert, 14 inches below top.

NOTE.—For bench-mark in Grenville Roman Catholic church see line from Grenville to Prescott.

844 In small stone and concrete culvert under Canadian Pacific railway, 1¾ miles west of Calumet and at mileage 61·2 from Montreal. South face of culvert.

845 In small stone and concrete culvert under Canadian Pacific railway, 1¼ miles east of Pointe-au-Chêne and at mileage 63·6 from Montreal. North face of culvert.

846 In deck truss bridge over Little Salmon river, 2¼ miles west of Pointe-au-Chêne and at mileage 67·2 from Montreal. Northeast retaining wall, west end of north face, first course of stonework below coping.

847 In Fassett Lumber company's office, directly opposite Fassett station. East concrete foundation wall, 10 inches below woodwork and 14 inches from southeast corner of building.

848 In square stone and concrete culvert under Canadian Pacific railway, ½ mile east of Montebello and at mileage 73·9 from Montreal. West end of south face of culvert.

849 In stone and concrete arch culvert under Canadian Pacific railway, ½ mile west of Montebello and 200 feet east of mile post 75 from Montreal. Northeast retaining wall, east end of north face, third course of stonework below top.

850 In shallow rock cut on Canadian Pacific railway, ¼ mile east of Papineauville station, 220 feet west of easterly switch of passing track and 330 feet east of an old stone culvert. North side of cut, near centre.

850–A In flat outcrop of rock, 1 mile west of Papineauville and 1 foot north of north line of Canadian Pacific railway right of way—opposite three farm buildings. Copper bolt set vertically, 40 feet west of a gate in right of way fence and 100 feet east of mile post 80 from Montreal.

851 In square stone and concrete culvert under Canadian Pacific railway, 2½ miles west of Papineauville and at mileage 81·4 from Montreal. West abutment, north face, fourth course of stonework below top.

852 In small rock cut on Canadian Pacific railway, 1½ miles west of Plaisance and 360 feet west of mile post 85 from Montreal—the second rock cut west of bridge over Petite Nation river. South side of cut, near east end.

852–A In large mass of rock, 2 miles west of Plaisance, 450 feet north of north line of Canadian Pacific railway right of way and at mileage 85·7 from Montreal—directly behind an old barn. West face of rock, about 35 feet from north end.

853 In small stone and concrete culvert under Canadian Pacific railway, 3¾ miles east of Thurso and at mileage 86·9 from Montreal. East end of north face of culvert.

854 In Roman Catholic church at Thurso. West (side) wall, 54 feet from front of building and about 2 feet above ground.

855 In top of concrete bench-mark pier, 1 mile west of Lochaber flag-station, 8 feet south of north line of Canadian Pacific railway right of way and 12 feet east of mile post 95 from Montreal—about 20 feet west of a small stone culvert.

856 In stone and concrete culvert under Canadian Pacific railway, 1⅓ miles east of Buckingham Junction and at mileage 98·6 from Montreal. East end of south face of culvert.

857 In stone and concrete culvert under Canadian Pacific railway, ⅔ mile west of Buckingham Junction and at mileage 100·6 from Montreal. West end of north face of culvert, third course of stonework below top.

858 In small stone and concrete culvert under Canadian Pacific railway, ½ mile west of Angers and at mileage 104·2 from Montreal. Centre of south face of culvert.

859 In large stone and concrete arch culvert under Canadian Pacific railway, 2½ miles west of Angers, and at mileage 106·3 from Montreal. North-east retaining wall, east end of north face, fourth course of stonework below top.

860 In steel truss bridge over Blanche river, 1,000 feet east of East Templeton station, on Canadian Pacific railway. Southwest retaining wall, south face, 30 inches west of rear (or west face) of west abutment and in third course of stonework below top.

861 In Roman Catholic church at Ste. Rose-de-Lima, about ⅓ mile north of East Templeton station. West wall of westerly transept, 8 feet 6 inches from north wall and directly above first basement window north of a small doorway.

862 In small stone and concrete culvert under Canadian Pacific railway, 1¾ miles east of Gatineau flag-station and at mileage 112·6 from Montreal. North face of culvert.

862–A In top of a stone monument, 1¼ miles east of Gatineau flag-station, 10 feet south of south line o Canadian Pacific railway right of way and at mileage 113·1 from Montreal—3 feet west o west line of road between lots 22 and 23, township of Templeton.

863 In Canadian Pacific railway bridge over Gatineau river, 2½ miles northeast of Hull. West face of east abutment, 6 feet from north end of abutment, and in nineteenth course of stonework below top.

864 In Roman Catholic church at Pointe Gatineau. West (side) wall, 15 feet from face of buttress at southwest corner of building and in water table course of stonework.

462 In cement storehouse at Canada Cement company's plant 1¼ miles north of Hull, beside Canadian Pacific railway. East wall of storehouse (a large concrete building), east face of most southerly buttress, 1 foot above ground and 95 feet from Canadian Pacific railway's Ottawa-Maniwaki track.

BENCH-MARKS BETWEEN ST. MARTIN JUNCTION AND THREE RIVERS, QUE., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 19.

684–B In square stone and concrete culvert under Canadian Pacific railway, 1,120 feet southwest of Le Cap flag-station and at mileage 0·7 from St. Martin Junction. Northwest face of culvert, 9 inches below top and 30 inches from side of water-passage.

685–B In square stone and concrete culvert under Canadian Pacific railway, 2¼ miles southwest of St. Vincent-de-Paul and at mileage 2·6 from St. Martin Junction. Southeast face of culvert, 14 inches below top and 8 inches from side of water-passage.

686–B In tile culvert under Canadian Pacific railway, ½ mile southwest of St. Vincent-de-Paul station and at southwesterly switch of passing-track. Southeast concrete face-wall of culvert.

687–B In Canadian Pacific railway bridge over rivière-des-Milles Iles, between De Sales and Terrebonne. Stone retaining wall behind southwest abutment, southeast end of northeast face, 34 inches above bridge seat.

688–B In Roman Catholic church at De Sales. Front (or north) wall, north face of corner stone at northwest corner of building, first course above water table course.

689–B In Roman Catholic church at Mascouche. Front (or east) wall, 4 feet from southeast corner of building and in first course of stonework below water table course.

690–B In small plate girder bridge on Canadian Pacific railway, 1¼ miles northeast of Mascouche and at mileage 15·5 from St. Martin Junction. Stone retaining wall behind southwest abutment, southeast face, second course below coping.

691–B In stone and concrete culvert under Canadian Pacific railway, 1,200 feet northeast of Cabane Ronde flag-station and at mileage 17·5 from St. Martin Junction. Northeast end of northwest face of culvert, 13 inches below top.

692–B In concrete arch culvert under Canadian Pacific railway, 1½ miles southwest of L'Epiphanie and at mileage 21·3 from St. Martin Junction. Northeast end of southeast face of culvert, 1 foot below top.

693–B In Roman Catholic church at L'Epiphanie. Front (or south) wall, 30 inches from east side of buttress at southwest corner of building and in water table course of stonework.

694–B In plate girder bridge over St. Esprit river, 1¾ miles northeast of L'Epiphanie and at mileage 24·5 from St. Martin Junction. Stone retaining wall behind northeast abutment, northwest end of southwest face, third course above bridge seat.

695–B In steel truss bridge over L'Assomption river, 1 mile southwest of Vaucluse flag-station. Stone retaining wall behind southwest abutment, southeast end of northeast face, second course above bridge seat.

696–B In square stone and concrete culvert under Canadian Pacific railway, 2 miles northeast of Lavaltrie and at mileage 32·4 from St. Martin Junction. Northeast end of northwest face of culvert, 8 inches below top.

697–B In square stone and concrete culvert under Canadian Pacific railway, 1,200 feet northeast of Lanoraie station. Southwest end of southeast face of culvert, 8 inches below top.

698–B In plate girder bridge over Chaloupe river, 1 mile southwest of Berthier Junction and at mileag 42·9 from St. Martin Junction, Stone retaining wall behind northeast abutment, northwe end of southwest face, second course below concrete coping.

699–B In large square stone and concrete culvert under Canadian Pacific railway, 1½ miles southwest of St. Cuthbert and at mile post 46 from St. Martin Junction. Southeast face of culvert, 38 inches below top and 15 inches from side of water-passage.

700–B In plate girder bridge over Chicot river, 800 feet southwest of St. Cuthbert station. Stone retaining wall behind northeast abutment, northwest end of southwest face, second course above bridge seat.

701–B In square stone and concrete culvert under Canadian Pacific railway, 2 miles southwest of St Barthélemi and at mileage 50·2 from St. Martin Junction. Southwest end of southeast face of culvert, 1 foot below top.

702–B In small plate girder bridge on Canadian Pacific railway, 1 mile northeast of St. Barthélemi and at mileage 53·2 from St. Martin Junction. Southwest abutment, northwest face, first course of stonework below bridge seat.

703–B In Canadian Pacific railway bridge over Maskinongé river, 1,000 feet southwest of Maskinongé station. Stone and concrete retaining wall behind southwest abutment, southeast end of northeast face, 4 feet 8 inches above bridge seat.

704–B In Roman Catholic church at Maskinongé. Front (or east) wall, 4 feet from southeast corner of building and in water table course of stonework.

705–B In post office at Louiseville. Front wall, 11 feet 6 inches west of west wall of clock tower, in cap stone over a basement window.

706–B In Canadian Pacific railway bridge over rivière-du-Loup, ¼ mile northeast of Louiseville station. Stone retaining wall behind northeast abutment, northwest end of southwest face, third course above bridge seat.

707–B In square stone and concrete culvert under Canadian Pacific railway, 2 miles southwest of Yamachiche and at mileage 65·4 from St. Martin Junction. Southwest end of southeast face of culvert, 9 inches below top.

708–B In Roman Catholic church at Yamachiche. Front (or north) wall, 4 feet from northeast corner of building and in second course of stonework above concrete floor of portico.

709–B In plate girder bridge over Yamachiche river, 1½ miles northeast of Yamachiche and at mileage 68·8 from St. Martin Junction. Stone and concrete retaining wall behind northeast abutment, northwest end of southwest face, second course above bridge seat.

710–B In plate girder bridge on Canadian Pacific railway, 3 miles southwest of Pointe-du-Lac and at mileage 71·4 from St. Martin Junction. Stone and concrete retaining wall behind southwest abutment, southeast end of northeast face, 42 inches above bridge seat.

711–B In plate girder bridge on Canadian Pacific railway, ⅓ mile southwest of Pointe-du-Lac and at mile post 74 from St. Martin Junction. Stone retaining wall behind southwest abutment, southeast end of northeast face, second course above bridge seat.

712–B In square stone and concrete culvert under Canadian Pacific railway, 4 miles southwest of Three Rivers and at mileage 78·4 from St. Martin Junction. Northeast end of northwest face of culvert, 6 inches below top.

713–B In Le Jeune street steel bridge over Canadian Pacific railway, ⅓ mile south of Three Rivers station. The bench mark is in the square concrete pier which is at the south side of the bridge and between main line track and Grand Mère branch; it faces the former track and is about 2 feet above ground.

714–B In library immediately behind and connected with Roman Catholic cathedral at Three Rivers. West (side) wall, 40 inches south of Royale street wall and in third course of stonework below water table course.

715–B In post office at Three Rivers. West (side) wall, second course of stonework below water table course, 5 feet south of wall facing Notre Dame street and 12 feet north of side entrance to Inland Revenue offices.

716–B In armoury at Three Rivers. Front wall—facing St. Francois-Xavier street; third course of stonework below brickwork, between second and third basement windows south of main entrance.

BENCH MARKS BETWEEN GRENVILLE, QUE., AND PRESCOTT, ONT., VIA CANADIAN NORTHERN RAILWAY TO HAWKESBURY, GRAND TRUNK RAILWAY TO ST. POLYCARPE JUNCTION, CANADIAN PACIFIC RAILWAY TO CORNWALL, AND GRAND TRUNK RAILWAY TO PRESCOTT.

Elevations on page 20.

Note—These descriptions are written with the assumption that the railways run in a southerly direction from Grenville to Glen Robertson, thence southeasterly to St. Polycarpe Junction, thence southwesterly to Cornwall, and thence westerly to Prescott.

865 In Roman Catholic church at Grenville. East (side) wall, 13 feet south of south wall of transept and in water table course of stonework.

866 In Canadian Northern railway bridge over Grenville canal, immediately north of bridge over Ottawa river between Grenville and Hawkesbury. Stone retaining wall behind north abutment, east end of south face, second course above bridge seat.

867 In Main street subway under Canadian Northern railway in the town of Hawkesbury. North concrete abutment of subway, centre of south face, about 2 feet above street level.

868 In Roman Catholic church at Hawkesbury. East wall of main tower (at northeast corner of church), 8 feet from south wall of tower and in second course of stonework below water table course.

869 In post office at Hawkesbury. Front wall, second course of stonework below brickwork, 2 feet west of west wall of vestibule at easterly entrance.

870 In southwest face of large boulder, 4 miles south of Hawkesbury, 135 feet east of east line of Grand Trunk railway right of way, 300 feet north of mile post 17 from Glen Robertson and 440 feet north of private crossing leading to house and barns of T. Sproule.

871 In square concrete culvert under Canadian Pacific railway, 0·4 mile east of Grand Trunk railway diamond crossing near Vankleek Hill and at mileage 32·8 from Vaudreuil. West end of south face of culvert.

872 In flat mass of rock, 2 miles south of Vankleek Hill, 21 feet east of west line of Grand Trunk railway right of way and 1,260 feet north of a diagonal road crossing. Copper bolt set vertically.

873 In Grand Trunk railway bridge over Rigaud river, 1 mile north of Dalkeith. West face of concrete retaining wall behind north abutment, 3 feet 9 inches above bridge seat.

874 In a galvanized iron sheathed storehouse on east side of Grand Trunk railway, 350 feet south of Dalkeith station. West concrete foundation wall, 1 foot below sheathing and 27 feet from northwest corner of building.

875 In east face of large granite boulder, 870 feet south of Glen Sandfield flag-station and 15 feet east of west line of Grand Trunk railway right of way.

876 In top of concrete bench mark pier, 3 feet west of east line of Grand Trunk railway right of way (Hawkesbury-Glen Robertson line), 172 feet north of switch stand at north end of Glen Robertson Y, and 1,040 feet north of main line of Ottawa division.

877 In Roman Catholic church at Glen Robertson. East (side) wall, 35 feet from front of building and in water table course of stonework.

878 In open culvert under Grand Trunk railway, 2 miles southeast of Glen Robertson and at mileage 70·15 from Alburgh Junction. Southeast stone and concrete abutment, northeast end of northwest face, 6 feet below bridge seat.

879 In small plate girder bridge on Grand Trunk railway, $\frac{1}{4}$ mile northwest of Ste. Justine. Southwest face of west concrete retaining wall, 30 inches below top and 5 feet 6 inches from northwest end of retaining wall.

880 In square concrete culvert under Grand Trunk railway, $1\frac{3}{4}$ miles northwest of St. Polycarpe Junction and at mileage 64·6 from Alburgh Junction. Southwest face-wall of culvert, 18 inches below top and 4 feet 6 inches from northwest end of face-wall.

881 In top of concrete bench-mark pier, 3 feet northeast of southwest line of Grand Trunk railway right of way, 2,060 feet northwest of diamond crossing of Canadian Pacific railway at St. Polycarpe Junction and 386 feet northwest of distant semaphore of interlocking plant.

92 In small open culvert under Grand Trunk railway, $\frac{1}{3}$ mile southeast of St. Polycarpe Junction. Southwest face of northwest abutment, fourth course of stonework below top.

93 In Canadian Pacific railway bridge over Delisle river, 1 mile west of St. Polycarpe Junction. West face of stone coping on southwest abutment of bridge.
NOTE.—Check levelling in 1918 indicates that the abutment has shifted slightly since the original levelling in 1908.

882 In Roman Catholic church at St. Polycarpe. North face of pilaster at northwest corner of building, second course of stonework below water table course.

883 In concrete arch culvert under Cornwall branch of Canadian Pacific railway, $1\frac{3}{4}$ miles southwest of St. Polycarpe Junction and 1,400 feet southwest of junction switch at Soulanges. Concrete coping on northwest end of culvert, northeast end of northwest face of coping.

884 In Roman Catholic church at St. Télesphore. West (side) wall, 19 feet from front wall of building and about 2 feet above ground.

885 In square concrete culvert under Canadian Pacific railway, 2 miles northeast of Bridge End and at mileage 3·3 from Soulanges. Southwest abutment of culvert, southeast end of northeast face of abutment.

886 In plate girder bridge over Baudet river, ¼ mile northeast of Bridge End, on Canadian Pacific railway. Concrete retaining wall behind southwest abutment, southeast end of northeast face, 21 inches above bridge seat.

887 In square concrete (double) culvert under Canadian Pacific railway, ¾ mile northeast of North Lancaster and at mileage 8·4 from Soulanges. Northeast end of northwest face of culvert, 10 inches below top.

888 In square concrete culvert under Canadian Pacific railway, 1¾ miles northeast of Glen Gordon flag-station and at mile post 11 from Soulanges. Southwest end of southeast face of culvert.

889 In square concrete culvert under Canadian Pacific railway, ½ mile southwest of Glen Gordon flag-station and at mileage 13·3 from Soulanges. Northeast end of northwest face of culvert.

890 In plate girder bridge over Raisin river, 700 feet southwest of Williamstown station, on Canadian Pacific railway. Concrete retaining wall behind southwest abutment, southeast end of northeast face, 40 inches above bridge seat.

891 In small square concrete culvert under Canadian Pacific railway, ¾ mile northeast of Glenbrook flag-station and at mileage 19·5 from Soulanges. Centre of southeast face of culvert.

892 In square concrete culvert under Canadian Pacific railway, 4¼ miles northeast of Cornwall and at mileage 23·3 from Soulanges. Northeast end of northwest face of culvert.

893 In top of concrete bench-mark pier, 240 feet northeast of diamond crossing of Grand Trunk and Canadian Pacific railways ⅔ mile east of G.T.R. station, Cornwall. The pier is 4 feet southeast of northwest line of C.P.R. right of way and 80 feet northeast of north fence of road running parallel to and on north side of G.T.R.

894 In Grand Trunk steel water tank at Cornwall station. Northeast face—5 inches below top—of northwesterly concrete footing.

490 In post office at Cornwall. South wall, 32 inches west of west wall of clock tower and in second course of stonework below water table course.

895 In large square stone and concrete culvert under Grand Trunk railway, ½ mile west of MilleRoches and at mileage 261·1 from Toronto. East end of north face of culvert.

896 In large square stone and concrete culvert under Grand Trunk railway, 1 mile west of Moulinette flag-station and at mileage 259·3 from Toronto. West end of south face of culvert

897 In stone arch bridge over Hoople creek 850 feet west of Wales station, on Grand Trunk railway. North face of east abutment, 4 feet from west face of abutment and in seventh course below coping.

898 In north face of flat limestone boulder, 2¼ miles west of Wales and at mileage 254·4 from Toronto—immediately north of north line of Grand Trunk railway right of way and at the east side of a farm crossing.

899 In stone arch culvert under Grand Trunk railway, 850 feet west of Farran Point flag-station and at mileage 252·1 from Toronto. Southeast wing wall of culvert, southeast face of top course of stonework.

900 In large open culvert under Grand Trunk railway, ½ mile west of Aultsville and at mileage 249·25 from Toronto. Northwest face of northwest wing wall, first course of stonework above seat of I-beams.

901 In stone monument erected in 1895 to commemorate the battle of Crysler's Farm; this is on the north bank of St. Lawrence river about 3½ miles west of Aultsville. The bench-mark is in north face of stone base of monument.

902 In stone arch culvert under Grand Trunk railway, 3¾ miles east of Morrisburg and at mileage 245·1 from Toronto. Southeast wing wall, second course of stonework above floor of culvert, first stone from mouth of water-passage.

903 In plate girder bridge on Grand Trunk railway, 1 mile east of Morrisburg. Northwest face of northeast retaining wall, sixth course of stonework below bridge seat, fourth stone from north end of east abutment.

904 In Grand Trunk station house at Morrisburg. Front (or north) wall, immediately east of westerly doorway and in second course of stonework above water table.

905 In east wall of vestry of St. James Anglican church, Morrisburg. In water table course of stonework, directly beneath a pair of windows facing street.

906 In large square stone and concrete culvert under Grand Trunk railway, 3 miles west of Morrisburg and at mileage 238·3 from Toronto—200 feet west of a highway crossing. East stone abutment, north end of west face, third course below concrete top of culvert.

907 In top of concrete bench-mark pier, 1 mile east of Iroquois, 5 feet north of south line of Grand Trunk railway right of way, 26 feet east of a farm crossing and 690 feet east of east end of a plate girder bridge at mileage 235·65 from Toronto.

908 In Grand Trunk station house at Iroquois. Front (or north) wall, immediately east of westerly doorway and in second course of stonework above water table.

909 In small open culvert under Grand Trunk railway, 2⅓ miles east of Cardinal and at mileage 231·6 from Toronto. West stone abutment, south end of east face, third course below seat of I-beams.

910 In large square concrete culvert under Grand Trunk railway, 1,100 feet east of Cardinal station. South face-wall of culvert, 30 inches below top and 6 inches from west end of face-wall.

911 In square stone and concrete culvert under Grand Trunk railway, 3¼ miles west of Cardinal and at mileage 225·9 from Toronto. West stone abutment, south end of east face, third course below concrete top of culvert.

912 In top of concrete bench-mark pier, 3¼ miles east of Prescott and 4 feet north of south line of Grand Trunk railway right of way—directly opposite a section tool-house. Also 396 feet west of west end of a plate girder bridge at mileage 223·4 from Toronto.

118 In Grand Trunk railway bridge over Canadian Pacific railway (Ottawa-Prescott line), 1½ miles east of Prescott. North face of east abutment, twentieth course of stonework below bridge seat.

913 In custom house at Prescott. Front (or south) wall, 8 feet east of main entrance and in third course of stonework above sidewalk.

914 In Roman Catholic church at Prescott. West (side) wall, 25 feet from front of building and in first course of stonework below water table course.

119 In Grand Trunk station house at Prescott. North face of corner stone at northeast corner of building, third course above water table.

BENCH-MARKS BETWEEN IVANHOE AND TORONTO (NORTH TORONTO), ONT., VIA CANADIAN PACIFIC RAILWAY.

Elevations on page 22.

187–G In square concrete culvert under Canadian Pacific railway, 2 miles west of Ivanhoe and at mileage 73·6 from Glentay. East end of north face of culvert, 1 foot below top.

188–G In square stone and concrete culvert under Canadian Pacific railway, 4¾ miles west of Ivanhoe and 40 feet west of westerly switch of Peterson passing-track. East end of north face of culvert, 15 inches below top.

189–G In side of concrete bench-mark pier, ½ mile east of Bonarlaw, 5 feet south of north line of Canadian Pacific railway right of way and 776 feet east of centre line of a road crossing.

190–G In square concrete culvert under Canadian Pacific railway, 4½ miles west of Bonarlaw and at mileage 84·7 from Glentay. East end of north face of culvert, 9 inches below top.

191–G In square concrete culvert under Canadian Pacific railway at mileage 86·9 from Glentay. East end of north face of culvert.

192–G In square concrete culvert under Canadian Pacific railway at mileage 89·1 from Glentay. West end of south face of culvert.

193–G In plate girder bridge on Canadian Pacific railway, 1¾ miles east of Havelock. Concrete retaining wall behind west abutment, south end of east face, 30 inches above bridge seat.

193-G-2 In small concrete highway bridge over a creek, about ½ mile west of Havelock station and 200 feet south of Canadian Pacific railway. West face of north abutment, 7 inches below top.

194–G In square concrete culvert under Canadian Pacific railway, 1 mile west of Havelock. East end of north face of culvert.

195–G In plate girder bridge on Canadian Pacific railway, 1¼ miles east of Norwood and at mileage 4·9 from Havelock. Southeast retaining wall, south face, first course of stonework below coping.

196–G In grain elevator about 480 feet west of Norwood station, on south side of Canadian Pacific railway. North concrete foundation wall, 3 feet above ground and 1 foot from northeast corner of building.

197–G In square concrete culvert under Canadian Pacific railway, 2 miles west of Norwood and at mileage 8·2 from Havelock. West end of north face of culvert, 1 foot below top.

198–G In square concrete culvert under Canadian Pacific railway, 1 mile east of Indian River and at mileage 13·6 from Havelock. Centre of north face of culvert.

199–G In square concrete culvert under Canadian Pacific railway, 1¾ miles west of Indian River and at mileage 16·3 from Havelock—at the east line of a highway crossing. Centre of north face of culvert.

200–G In square concrete (double) culvert under Canadian Pacific railway, 3¾ miles west of Indian River and and at mileage 18·3 from Havelock. East abutment, north end of west face, 4 feet below top of culvert.

201–G In square concrete culvert under Canadian Pacific railway, 3¼ miles east of Peterboro and at second telegraph pole west of mile post 21 from Havelock. Centre of south face of culvert.

202–G In Trent canal lift-lock at Peterboro. East tower, centre of south face, 3 feet above concrete floor at lower level.

203–G In armoury at Peterboro. South (or Murray street) wall, fourth course of stonework below brickwork, 2 feet from southwest corner of building.

204–G In Sacred Heart Roman Catholic church, Peterboro; corner of Aylmer and Romaine streets. West (side) wall, first course of stonework below water table course, between fourth and fifth buttresses from front of building.

205–G In top of concrete bench-mark pier, 1 mile west of Peterboro station, 3 feet south of north line of Canadian Pacific railway right of way and 370 feet west of west line of Monaghan road.

206–G In square concrete (double) culvert under Canadian Pacific railway, 4 miles west of Peterboro and at mileage 28·35 from Havelock. East abutment, north end of west face, 3 feet below top of culvert.

207–G In square concrete culvert under Canadian Pacific railway, 1½ miles east of Cavan and at mileage 31·7 from Havelock. East end of north face of culvert, 8 inches below top.

208–G In subway under Canadian Pacific railway (crossing of main road between Millbrook and Cavan), 1½ miles west of Cavan station and at mileage 34·6 from Havelock. Concrete retaining wall behind west abutment, south end of east face, 16 inches above bridge seat.

209–G In Canadian Pacific railway bridge over Grand Trunk railway (Millbrook-Omemee Junction line), ¾ mile east of Bethany Junction and 4¼ miles north of Millbrook. West abutment, south end of east face, thirteenth course of stonework below bridge seat.

210–G In plate girder bridge on Canadian Pacific railway, ¾ mile west of Bethany Junction and at mileage 39·4 from Havelock. Southwest retaining wall, south face, second course of stonework below coping.

211–G In triangular tile culvert under Canadian Pacific railway, 6 feet east of east wall of Manvers station house. South face of south concrete face-wall, 9 inches below top.

212–G In small concrete arch culvert under Canadian Pacific railway, 1½ miles east of Pontypool and 200 feet east of mile post 44 from Havelock. Centre of north face of culvert, 1 foot below top.

213–G In grain elevator about 630 feet west of Pontypool station, on south side of Canadian Pacific railway. North concrete foundation wall, 20 inches above door sill and 6 feet from northeast corner of building.

214–G In square concrete culvert under Canadian Pacific railway, 2¼ miles west of Pontypool and at mileage 47·6 from Havelock—at the east line of a highway crossing. Centre of south face of culvert.

215–G In top of concrete bench-mark pier, 4¼ miles east of Burketon, 9 feet south of north line of Canadian Pacific railway right of way and 72 feet east of east line of road allowance between townships of Manvers and Cartwright—directly opposite mile post 50 from Havelock.

216–G In Canadian Pacific section house about 350 feet west of Burketon station. (Front) or north concrete foundation wall, 14 inches below woodwork and 15 inches east of cellar window.

217–G In square concrete culvert under Canadian Pacific railway, ¾ mile west of Brady flag-station and at mile post 59 from Havelock—immediately west of a highway crossing. Centre of south face of culvert.

218–G In concrete arch cattle-pass under Canadian Pacific railway, 2½ miles east of Myrtle and at first telegraph pole west of mile post 61 from Havelock—immediately east of a highway crossing. West face of north face-wall of culvert, 1 foot below top.

219–G In Grand Trunk railway bridge over Canadian Pacific railway, ⅓ mile west of Myrtle C.P.R. station and ¾ mile north of Myrtle G.T.R. station. North face of south abutment, twelfth course of stonework below bridge seat, 25 feet from west end of abutment.

220–G In square concrete culvert under Canadian Pacific railway, ½ mile east of Dagmar flag-station and at mileage 66·7 from Havelock. East abutment, north end of west face, 4 feet 4 inches below top of culvert.

221–G In concrete arch subway under Canadian Pacific railway, ½ mile west of Glen Major flag-station and at mileage 69·3 from Havelock. Concrete coping on south end of subway, west end of south face of coping, 1 foot below top.

222–G In square concrete culvert under Canadian Pacific railway, 1½ miles east of Claremont and at mileage 71·1 from Havelock. Centre of north face of culvert.

223–G In square concrete (double) culvert under Canadian Pacific railway, 1¾ miles west of Claremont and at mileage 74·3 from Havelock. Near centre of south face of culvert, 15 inches below top. This is the farther west of two similar culverts about 750 feet apart.

224–G In large stone-arch culvert under Canadian Pacific railway, ¼ mile west of Atha Road flag-station and at mileage 76·3 from Havelock. North face of northwest retaining wall, first course of stonework below coping on north end of culvert.

225–G In large concrete arch culvert under Canadian Pacific railway, 1½ miles east of Locust Hill and at mileage 78·7 from Havelock. Concrete coping on south end of culvert, west end of south face of coping, 15 inches below top.

226–G In Canadian Pacific water tank (now disused) at Locust Hill. Circular masonry base of tank, 9 feet to the left of the doorway and in second course of stonework below door-sill.

227–G In large square concrete culvert under Canadian Pacific railway, 2½ miles west of Locust Hill and at mileage 82·3 from Havelock. East end of north face of culvert, 1 foot below top.

228–G In plate girder bridge on Canadian Pacific railway, 4 miles west of Locust Hill and at mileage 84·1 from Havelock. Concrete retaining wall behind west abutment, south end of east face, 3 feet above bridge seat.

229–G In large square concrete culvert under Peterboro subdivision of Canadian Pacific railway, ¾ mile east of Agincourt and at mileage 87·15 from Havelock. West end of north face of culvert, 10 inches below top.

230–G In Canadian Pacific railway bridge over Grand Trunk railway (Lindsay-Scarboro Junction line), ¾ mile west of Agincourt and at mile post 97 from Trenton. Concrete retaining wall behind east abutment, south end of west face, 15 inches above bridge seat.

231–G In square concrete culvert under Canadian Pacific railway, 2¾ miles west of Agincourt and at second telegraph pole east of mile post 99 from Trenton. West end of south face of culvert, 8 inches below top.

232–G In Canadian Pacific railway's steel trestle viaduct over Little Don river and Canadian Northern railway, 2¾ miles east of Leaside. Concrete retaining wall behind east abutment, north end of west face, 30 inches above bridge seat.

233–G In Canadian Pacific railway's steel trestle viaduct over Don river, 1 mile east of Leaside. Concrete retaining wall behind west abutment, south end of east face, 40 inches above bridge seat.

234–G In Canadian Pacific railway's re-enforced concrete viaduct over ravine followed by old belt-line railway, 1¼ miles east of North Toronto station. East concrete abutment, south face, 3 feet below top.

235–G In Yonge street subway under Canadian Pacific railway at North Toronto station. West concrete abutment, south end of east face, 2 feet above concrete sidewalk. Also 40 feet 6 inches north of north wall of Dominion Bank.

189 In old Canadian Pacific station house (now disused) at North Toronto. This bench mark has been rendered inaccessible by the reconstruction of the railway.

BENCH-MARKS BETWEEN BETHANY AND PORT HOPE, ONT., VIA GRAND TRUNK RAILWAY.

Elevations on page 23.

915 In top of concrete bench-mark pier, 1 mile north of Millbrook, on Grand Trunk railway's Millbrook-Omemee Junction line. Pier is 10 feet east of west line of right of way and 41 feet north of intersection of west line of right of way with north line of road allowance between concessions V and VI, township of Cavan.

916 In armory at Millbrook. Concrete foundation of front wall, west face of buttress at west side of main entrance, 15 inches below brickwork.

917 In steel and concrete subway under Grand Trunk railway, 1¼ miles south of Carmel flag-station and at mileage 12·7 from Port Hope. Concrete retaining wall behind south abutment, east end of north face, 3 feet above bridge seat.

918 In F. Smith's (red brick) residence in the village of Campbellcroft, on north side of main road, immediately east of Grand Trunk railway. Stone foundation of east wall, 5 inches below brickwork and 10 feet from southeast corner of building.

919 In top of concrete bench-mark pier at Quay flag-station, 5 feet east of west line of Grand Trunk railway right of way and 56 feet north of intersection of said line with north line of road allowance between concessions IV and V, township of Hope.

920 In Canadian Northern railway's steel trestle viaduct over Port Hope-Peterboro line of Grand Trunk railway, 1 mile north of Port Hope (Walton street). Concrete footing of steel column on north side of C.N.R. and on west side of G.T.R. track; centre of north face of footing, 4 feet below top.

921 In Canadian Pacific railway's viaduct over Port Hope-Peterboro line of Grand Trunk railway in the town of Port Hope. Second concrete pier from west end of viaduct, centre of west face of pier, 18 inches above G.T.R. rails.

172 In Port Hope town hall. West end of south wall, fourth course of stonework above sidewalk.

172–A In Port Hope post office. South face of corner stone at southwest corner of building, first course above sidewalk.

173 In Grand Trunk station house at Port Hope Junction. West face of corner stone at northwest corner of building, first course above platform.

BENCH MARKS BETWEEN MYRTLE AND WHITBY, ONT., VIA GRAND TRUNK RAILWAY.

Elevations on page 24.

922 In top of concrete bench-mark pier, $1\frac{1}{4}$ miles north of Brooklin, 4 feet west of east line of Grand Trunk railway right of way and 100 feet north of north line of road allowance between concessions VI and VII, township of Whitby.

923 In Anglican church at Brooklin, a frame building immediately east of Grand Trunk railway. West wall, 8 feet 6 inches from southwest corner of building, first course of stonework below woodwork.

924 In Canadian Northern railway bridge over Lyon brook, 1,100 feet west of Brooklin C.N.R. station and $\frac{3}{4}$ mile west of Grand Trunk railway diamond crossing. Concrete retaining wall behind east abutment, south end of west face, 3 feet above bridge seat.

925 In top of concrete bench-mark pier, $1\frac{1}{4}$ miles north of Whitby (town station), 4 feet east of west line of Grand Trunk railway right of way and 30 feet south of south line of road allowance between concessions II and III, township of Whitby.

926 In Whitby post office. King street wall, first course of stonework below water table course, 12 feet 6 inches west of west wall of clock tower.

180–A In St. John's Anglican church, $\frac{1}{4}$ mile southeast of Grand Trunk station, Whitby Junction. West end of front wall, second course of stonework above ground.

927 In chimney of Whitby water works pumping station on shore of lake Ontario at Port Whitby. Concrete base of chimney, centre of north face.

BENCH MARKS BETWEEN NORTH TORONTO AND MIMICO, ONT., VIA CANADIAN PACIFIC RAILWAY THROUGH WEST TORONTO, ISLINGTON AND "CANPA."

(*Elevations on page 24.*)

236–G In Spadina road subway under Canadian Pacific railway in the city of Toronto. West concrete abutment, south end of east face, 3 feet above concrete sidewalk. Also 24 feet north of south line of C.P.R. right of way.

237–G In Dovercourt road subway under Canadian Pacific railway in the city of Toronto. West concrete abutment, south end of east face, 3 feet above concrete sidewalk. Also 24 feet north of south line of C.P.R. right of way.

238–G In Weston road bridge over Canadian Pacific railway, West Toronto. Concrete pier at south end of steel truss and at east side of bridge; centre of north face of pier, 2 feet above concrete footing.

239–G In top of concrete bench-mark pier, $1\frac{1}{4}$ miles northwest of West Toronto station and between the tracks of Grand Trunk railway (Toronto-Stratford line) and Canadian Pacific railway (Toronto-Sudbury line), 37 feet southwest of the latter. Between sixth and seventh telegraph poles northwest of C.P.R. mile post 1 and 840 feet southeast of an overhead crossing of the Weston road.

240–G In West Toronto post office, corner of Dundas and Keele streets. Keele street wall, 30 inches north of entrance to Customs department and in third course of stonework below brickwork.

241–G In Runnymede road subway under Canadian Pacific railway, 1 mile west of Keele street, West Toronto. West concrete abutment, south end of east face, 3 feet above concrete sidewalk. Also 10 feet north of south line of C.P.R. right of way.

242–G In Canadian Pacific railway bridge over Humber river, ½ mile west of Lambton flag station. Northeast concrete retaining wall, 2 feet 8 inches below top and 5 feet 6 inches from east end of wall.

243–G In Canadian Pacific railway bridge over Mimico creek and Toronto Suburban (electric) railway, 850 feet east of Islington station. Concrete retaining wall behind west abutment, south end of east face, 2 feet above bridge seat.

244–G In square concrete culvert under Canadian Pacific railway, ¾ mile west of Islington and 300 feet east of junction switch at "Obico". West end of south face of culvert, 6 inches below top.

245–G In top of concrete bench-mark pier, 1¾ miles southwest of Mimico station, 3 feet northwest o southeast line of Grand Trunk railway right of way and 205 feet southwest of signal tower at "Canpa," the junction of C.P.R. cut-off from Islington with G.T.R. Toronto-Hamilton line.

191 In Grand Trunk railway bridge over Etobicoke creek, 3 miles southwest of Mimico. East retaining wall, northeast face of cap-stone.

TABLE II.

RESULTS OF PRECISE LEVELLING

MONTREAL TO HULL, QUE.

Run by W. N. McGrath and F. B. Reid.

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 818	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	818					203·377	818
818	826	0·9	0·9	−·012	−·012	182·493	826
826	827	2·1	3·0	+·010	−·002	95·966	827
827	828	1·6	4·6	−·007	−·009	67·439	828
828	829	2·9	7·5	−·014	−·023	107·077	829
829	830	2·0	9·5	+·003	−·020	142·997	830
830	831	2·5	12·0	−·010	−·030	86·944	831
831	832	3·1	15·1	+·011	−·019	149·569	832
832	833	3·4	18·5	+·004	−·015	151·486	833
833	834	2·7	21·2	−·012	−·027	189·391	834
834	835	3·1	24·3	−·022	−·049	219·092	835
835	835–A	3·9	28·2	+·029	−·020	232·358	835–A
835–A	836	0·4	28·6	−·003	−·023	244·081	836
835–A	837	6·6	34·8	+·025	+·005	242·655	837
837	838	4·9	39·7	+·008	+·013	224·278	838
838	839	0·5	40·2	+·004	+·017	207·085	839
839	840	5·9	46·1	+·026	+·043	261·608	840
840	841	4·3	50·4	+·024	+·067	251·889	841
841	842	2·1	52·5	+·004	+·071	222·425	842
842	843	0·3	52·8	−·002	+·069	199·142	843
843	844	4·1	56·9	−·003	+·066	188·815	844
844	845	2·4	59·3	+·010	+·076	188·998	845
845	846	3·6	62·9	+·010	+·086	162·610	846
846	847	3·5	66·4	−·028	+·058	169·007	847
847	848	3·2	69·6	+·011	+·069	159·285	848
848	849	1·1	70·7	+·009	+·078	169·230	849
849	850	3·8	74·5	−·003	+·075	155·218	850
850	850–A	1·2	75·7	+·006	+·081	186·272	850–A
850–A	851	1·4	77·1	−·007	+·074	174·447	851
851	852	3·7	80·8	−·029	+·045	184·202	852
852	852–A	0·7	81·5	+·005	+·050	186·700	852–A
852–A	853	1·2	82·7	+·013	+·063	181·362	853
853	854	3·9	86·6	+·021	+·084	184·401	854
854	855	4·8	91·4	+·029	+·113	175·772	855
855	856	3·6	95·0	−·012	+·101	178·075	856
856	857	2·0	97·0	−·002	+·099	183·565	857
857	858	3·7	100·7	+·006	+·105	180·897	858
858	859	2·1	102·8	+·020	+·125	160·162	859
859	860	3·1	105·9	+·006	+·131	149·968	860
860	861	0·5	106·4	−·004	+·127	186·047	861
861	862	3·2	109·6	+·026	+·153	176·855	862
862	862–A	0·5	110·1	+·004	+·157	174·844	862–A
862–A	863	2·8	112·9	−·010	+·147	153·910	863
863	864	1·4	114·3	−·003	+·144	157·706	864
863	462	1·3	114·2	−·017	+·130	163·315	462*

* The observed elevation of the junction bench-mark 462 was 163·565.

RESULTS OF PRECISE LEVELLING

ST. MARTIN JUNCTION TO THREE RIVERS, QUE.

Run by W. N. McGrath.

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 829	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
829	829					107·077	829
829	684–B	0·4	0·4	+·003	+·003	99·007	684–B
684–B	685–B	1·9	2·3	−·030	−·027	70·232	685–B
685–B	686–B	1·7	4·0	−·005	−·032	79·599	686–B
686–B	687–B	5·8	9·8	−·061	−·093	50·781	687–B
687–B	688–B	0·2	10·0	+·001	−·092	57·185	688–B
687–B	689–B	4·9	14·7	−·004	−·097	69·106	689–B
689–B	690–B	2·5	17·2	+·021	−·076	52·326	690–B
690–B	691–B	2·0	19·2	+·004	−·072	55·019	691–B
691–B	692–B	3·8	23·0	−·002	−·074	60·547	692–B
692–B	693–B	2·3	25·3	−·018	−·092	79·448	693–B
693–B	694–B	2·3	27·6	−·008	−·100	64·479	694–B
694–B	695–B	1·2	28·8	+·021	−·079	58·508	695–B
695–B	696–B	6·7	35·5	−·010	−·089	69·194	696–B
696–B	697–B	3·6	39·1	+·005	−·084	68·916	697–B
697–B	698–B	7·0	46·1	+·008	−·076	53·510	698–B
698–B	699–B	3·1	49·2	−·020	−·096	33·105	699–B
699–B	700–B	1·3	50·5	−·011	−·107	34·400	700–B
700–B	701–B	2·9	53·4	+·006	−·101	35·437	701–B
701–B	702–B	3·1	56·5	−·003	−·104	29·564	702–B
702–B	703–B	4·3	60·8	−·021	−·125	44·865	703–B
703–B	704–B	0·3	61·1	·000	−·125	52·225	704–B
703–B	705–B	4·6	65·4	+·034	−·091	44·209	705–B
705–B	706–B	0·8	66·2	−·015	−·106	41·087	706–B
706–B	707–B	3·3	69·5	+·001	−·105	33·595	707–B
707–B	708–B	2·2	71·7	+·018	−·087	39·454	708–B
708–B	709–B	1·9	73·6	+·016	−·071	39·623	709–B
709–B	710–B	2·6	76·2	+·008	−·063	34·997	710–B
710–B	711–B	2·6	78·8	+·027	−·036	61·888	711–B
711–B	712–B	4·4	83·2	+·009	−·027	35·748	712–B
712–B	713–B	3·6	86·8	+·035	+·008	53·290	713–B
713–B	714–B	0·4	87·2	+·009	+·017	54·424	714–B
714–B	715–B	0·3	87·5	−·003	+·014	53·963	715–B
714–B	716–B	0·2	87·4	+·003	+·020	57·903	716–B

RESULTS OF PRECISE LEVELLING

GRENVILLE, QUE., TO PRESCOTT, ONT.

Run by F. B. Reid.

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 842	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	842					222·425	842
842	865	2·2	2·2	−·011	−·011	166·467	865
865	866	1·3	3·5	+·004	−·007	170·793	866
866	867	0·6	4·1	−·002	−·009	140·755	867
867	868	0·4	4·5	+·005	−·004	149·239	868
868	869	0·2	4·7	·000	−·004	147·323	869
869	870	4·0	8·7	+·009	+·005	236·254	870
870	871	2·2	10·9	+·002	+·007	255·516	871
871	872	3·9	14·8	·000	+·007	310·869	872
872	873	3·6	18·4	−·011	−·004	210·867	873
873	874	1·0	19·4	−·014	−·018	230·248	874
874	875	3·6	23·0	+·029	+·011	236·128	875
875	876	3·0	26·0	−·003	+·008	251·492	876
876	877	0·8	26·8	·000	+·008	297·465	877
876	878	1·8	27·8	+·004	+·012	239·943	878
878	879	2·4	30·2	+·028	+·040	244·111	879
879	880	3·2	33·4	−·033	+·007	204·722	880
880	881	1·5	34·9	−·005	+·002	193·423	881
881	92	0·7	35·6	+·003	+·005	186·360	92*
92	882	2·3	37·9	+·014	+·019	180·578	882
92	93	1·4	37·0	−·007	−·002	193·322	93
93	883	0·7	37·7	−·004	−·006	194·668	883
883	884	2·0	39·7	−·021	−·027	227·814	884
884	885	1·0	40·7	+·009	−·018	197·658	885
885	886	1·7	42·4	−·013	−·031	195·080	886
886	887	3·4	45·8	−·010	−·041	187·404	887
887	888	2·6	48·4	−·008	−·049	185·620	888
888	889	2·3	50·7	−·011	−·060	180·978	889
889	890	3·1	53·8	+·002	−·058	178·820	890
890	891	3·1	56·9	+·014	−·044	172·538	891
891	892	3·7	60·6	−·015	−·059	180·738	892
892	893	3·3	63·9	−·027	−·086	187·733	893

*See next page.

RESULTS OF PRECISE LEVELLING

GRENVILLE, QUE., TO PRESCOTT, ONT.

Run by F. B. Reid.

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 842	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
[illegible] 893	894	0·7	64·6	−·006	−·092	193·584	894
894	490	1·1	65·7	−·014	−·106	194·246	490*
894	895	5·2	69·8	+·026	−·066	227·868	895
895	896	1·8	71·6	−·007	−·073	220·374	896
896	897	2·7	74·3	·000	−·073	227·889	897
897	898	2·1	76·4	−·008	−·081	239·870	898
898	899	2·3	78·7	+·004	−·077	238·823	899
899	900	2·9	81·6	−·024	−·101	240·621	900
900	901	3·6	85·2	−·026	−·127	243·153	901
901	902	1·7	86·9	+·007	−·120	224·226	902
902	903	2·6	89·5	+·019	−·101	244·026	903
903	904	1·1	90·6	+·016	−·085	273·572	904
904	905	0·4	91·0	−·007	−·092	264·714	905
904	906	3·1	93·7	+·016	−·069	249·288	906
906	907	2·5	96·2	−·019	−·088	254·819	907
907	908	1·0	97·2	+·008	−·080	247·965	908
908	909	3·2	100·4	−·002	−·082	281·055	909
909	910	2·1	102·5	+·019	−·063	274·717	910
910	911	3·5	106·0	+·001	−·062	279·490	911
911	912	2·6	108·6	−·016	−·078	285·627	912
912	118	1·7	110·3	−·013	−·091	288·676	118*
118	913	1·3	111·6	−·001	−·092	268·347	913
913	914	0·2	111·8	−·003	−·095	300·829	914
914	119	0·6	112·4	+·001	−·094	313·837	119*

*The observed elevations of the junction bench-marks 92, 490, 118, and 119 were, respectively, 136·273, 194·360, 288·893, and [illegible] 314·060. See Note after description of bench-mark 93 (Table I).

Connections with Public Works Dept's bench-marks:—

CCCCLI—Hawkesbury Roman Catholic church, Elev. 147·513.

DLXII—G.T.R station, Cornwall, Elev. 194·094.

DLXXX—G.T.R. culvert, Cornwall Jct., Elev. 196·026.

RESULTS OF PRECISE LEVELLING

IVANHOE TO TORONTO, ONT.

Run by W. N. McGrath and F. B. Reid

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 113	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	179–G		107·1		+·067	586·659	179–G
179–G	187–G	3·0	110·1	−·018	+·049	616·682	187–G
187–G	188–G	2·8	112·9	−·022	+·027	556·354	188–G
188–G	189–G	3·4	116·3	−·018	+·009	579·882	189–G
189–G	190–G	4·8	121·1	+·008	+·017	629·798	190–G
190–G	191–G	2·3	123·4	+·009	+·026	639·274	191–G
191–G	192–G	2·1	125·5	−·008	+·018	640·805	192–G
192–G	193–G	2·9	128·4	−·006	+·012	644·532	193–G
193–G	194–G	2·8	131·2	+·001	+·013	701·996	194–G
194–G	193–G–2	0·6	131·8	·000	+·013	698·643	193–G–2
194–G	195–G	3·8	135·0	+·001	+·014	684·705	195–G
195–G	196–G	1·3	136·3	−·003	+·011	677·081	196–G
196–G	197–G	2·1	138·4	−·011	·000	732·014	197–G
197–G	198–G	5·4	143·8	+·002	+·002	704·790	198–G
198–G	199–G	2·7	146·5	+·019	+·021	692·663	199–G
199–G	200–G	2·0	148·5	+·002	+·023	694·012	200–G
200–G	201–G	2·7	151·2	+·020	+·043	672·145	201–G
201–G	202–G	2·7	153·9	+·026	+·069	637·436	202–G
202–G	203–G	1·5	155·4	+·012	+·081	673·365	203–G
203–G	204–G	1·3	156·7	−·014	+·067	634·497	204–G
204–G	205–G	0·8	157·5	+·003	+·070	644·963	205–G
205–G	206–G	3·1	160·6	−·018	+·052	629·593	206–G
206–G	207–G	3·3	163·9	−·001	+·051	636·484	207–G
207–G	208–G	3·0	166·9	+·017	+·068	697·105	208–G
208–G	209–G	3·3	170·2	+·029	+·097	840·213	209–G
209–G	210–G	1·5	171·7	+·001	+·098	893·540	210–G
210–G	211–G	2·0	173·7	+·009	+·107	967·287	211–G
211–G	212–G	2·5	176·2	+·007	+·114	1044·932	212–G
212–G	213–G	1·6	177·8	+·016	+·130	1072·488	213–G
213–G	214–G	2·1	179·9	−·021	+·109	1090·374	214–G
214–G	215–G	2·4	182·3	+·011	+·120	1099·638	215–G
215–G	216–G	4·4	186·7	+·025	+·145	1056·731	216–G
216–G	217–G	4·6	191·3	+·023	+·168	1028·773	217–G
217–G	218–G	2·1	193·4	+·014	+·182	961·733	218–G
218–G	219–G	2·9	196·3	−·005	+·177	870·963	219–G
219–G	220–G	2·9	199·2	−·009	+·168	852·810	220–G
220–G	221–G	2·6	201·8	−·017	+·151	820·468	221–G
221–G	222–G	1·7	203·5	−·015	+·136	818·233	222–G
222–G	223–G	3·1	206·6	+·012	+·148	810,017	223–G
223–G	224–G	2·1	208·7	+·024	+·172	729·197	224–G
224–G	225–G	2·4	211·1	+·023	+·195	633·175	225–G
225–G	226–G	1·3	212·4	+·006	+·201	664·809	226–G
226–G	227–G	2·4	214·8	+·005	+·206	565·714	227–G
227–G	228–G	1·7	216·5	−·007	+·199	532·707	228–G

RESULTS OF PRECISE LEVELLING
IVANHOE TO TORONTO, ONT.

Run by W. N. McGrath and F. B. Reid.

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 113	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
228–G	229–G	3·0	219·5	+·002	+·201	559·687	229–G
229–G	230–G	1·6	221·1	+·003	+·204	566·110	230–G
230–G	231–G	2·0	223·1	·000	+·204	557·692	231–G
231–G	232–G	2·0	225·1	+·006	+·210	461·016	232–G
232–G	233–G	1·8	226·9	+·006	+·216	410·169	233–G
233–G	234–G	2·0	228·9	+·005	+·221	425·869	234–G
234–G	235–G	1·3	230·2	+·014	+·235	399·410	235–G
235–G	189	.....	230·2	−·004	+·231	405·106	189*

* The observed elevation of the junction bench-mark 189 was 404·754.

Connections with Public Works Dept's bench-marks:—

MCCXXII—Trent Canal lift-lock, Peterboro, Elev. 636·503.

MCCXXI—C.P.R. bridge over Otonabee river, Peterboro, Elev. 631·356.

DCXXII—Old C.P.R. station, North Toronto, Elev. 405·401.

RESULTS OF PRECISE LEVELLING
BETHANY TO PORT HOPE, ONT.

Run by F. B. Reid

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 209–G	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	209–G					840·213	209–G
209–G	915	3·2	3·2	+·007	+·007	819·551	915
915	916	1·5	4·7	+·013	+·020	701·538	916
916	917	5·8	10·5	−·031	−·011	806·809	917
917	918	3·2	13·7	−·029	−·040	630·602	918
918	919	4·0	17·7	−·017	−·057	480·661	919
919	920	4·3	22·0	+·034	−·023	310·087	920
920	172–A	1·0	23·0	+·008	−·015	267·835	172–A*
172–A	172	0·1	23·1	+·004	−·011	257·027	172
172–A	921	0·3	23·3	−·007	−·022	271·471	921
921	173	0·3	23·6	+·003	−·019	287·835	173*

* The observed elevations of the junction bench-marks 172-A and 173 were respectively 267·297 and 287·311.

RESULTS OF PRECISE LEVELLING

MYRTLE TO WHITBY, ONT.

Run by F. B. Reid

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 219-G	Discrepancy		Elevation above mean sea level	Bench-Mark
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	219-G					870·963	219-G
219-G	922	3·4	3·4	−·004	−·004	611·501	922
922	923	1·2	4·6	+·004	−·000	539·338	923
923	924	2·5	7·1	−·004	−·004	471·496	924
924	925	3·0	10·1	+·002	−·002	359·489	925
925	926	1·3	11·4	−·005	−·007	314·060	926
926	180-A	1·9	13·3	−·008	−·015	288·846	180-A*
180-A	927	1·4	14·7	−·006	−·021	250·356	927

* The observed elevation of the junction bench-mark 180-A was 288·379.

RESULTS OF PRECISE LEVELLING

NORTH TORONTO TO MIMICO, ONT.

Run by F. B. Reid

Bench-Mark		Distance between successive bench-marks	Distance from bench-mark 235-G	Discrepancy		Elevation above mean sea level	Bench-Mark.
From	To			Partial	Total		
No.	No.	Miles	Miles	Feet	Feet	Feet	No.
	235-G	.....	.....	.....	.....	399·410	235-G
235-G	236-G	0·9	0·9	−·008	−·008	403·280	236-G
236-G	237-G	1·3	2·2	−·006	−·014	398·935	237-G
237-G	238-G	1·4	3·6	+·004	−·010	395·794	238-G
238-G	239-G	1·2	4·8	.....	.....	.....	239-G†
238-G	240-G	0·4	4·0	+·005	−·005	389·790	240-G
238-G	241-G	1·1	4·7	+·002	−·008	390·399	241-G
241-G	242-G	1·5	6·2	+·004	−·004	396·424	242-G
242-G	243-G	1·2	7·4	+·010	+·006	399·294	243-G
243-G	244-G	1·0	8·4	+·015	+·021	397·692	244-G
244-G	245-G	2·7	11·1	+·023	+·044	316·081	245-G
245-G	191	1·3	12·4	+·017	+·061	288·356	191*

† The elevation of bench-mark 239-G has not yet been determined.
* The observed elevation of the junction bench-mark 191 was 288·353.

TABLE III.

RAIL ELEVATIONS, MONTREAL TO HULL, QUE.

(Elevations taken in 1917 and 1918)

		FEET.
Canadian Pacific Railway—	Montreal, Place Viger Station	58·1
"	Hochelaga	77·2
"	Angus	160·3
"	Mile End	222·7
"	Breslay (signal tower)	193·9
"	Jacques Cartier Junction	98·2
"	Bordeaux	75·4
"	Rivière-des-Prairies; water, June 12, 1917, 56·8; rail	73·8
"	Laval Rapides	74·3
"	St. Martin	107·2
"	St. Martin Junction	109·2
"	Ste. Rose	90·0
"	Rivière-des-Milles Iles; water, June 13, 1917, 69·0; rail	89·5
"	Rosemere	91·3
"	Ste. Thérèse	121·3
"	St. Augustin	223·4
"	Ste. Scholastique	237·2
"	St. Hermas	255·3
"	Lachute	228·0
"	North river; water, September 20, 1917, 194·0; rail	209·1
"	Canadian Northern railway (diamond crossing)	250·0
"	Staynerville	260·2
"	Chatboro	311·8
"	Magnesite	256·4
"	Grenville	209·1
"	Calumet	195·0
"	Rouge river; water, October 9, 1917, 132·9; rail	178·1
"	Pointe-au-Chêne	187·1
"	Fassett	169·9
"	Kinonge river; water, October 26, 1917, 128·9; rail	161·4
"	Montebello	170·7
"	Papineauville	155·0
"	Plaisance	187·2
"	Petite Nation river; water, May 9, 1918, 134·7; rail	185·7
"	Thurso	185·9
"	Blanche river; water, May 14, 1918, 135·5; rail	170·7
"	Lochaber	180·5
"	Buckingham Junction	190·0
"	Lièvre river; rail at centre of bridge	188·3
"	Angers	187·5
"	Little Blanche river; water, May 20, 1918, 143·4; rail	168·9
"	Blanche river; water, May 22, 1918, 137·8; rail	154·8
"	East Templeton	159·3
"	Gatineau	178·2
"	Gatineau river; water, May 25, 1918, 138·7; rail	182·1
"	Canadian Pacific railway, Ottawa-Maniwaki line (under crossing) rail 151·7; North Shore line rail	177·1
"	Hull	190·9

RAIL ELEVATIONS, ST. MARTIN JUNCTION TO THREE RIVERS, QUE.

(Elevations taken in 1917)

Canadian Pacific Railway—	St. Martin Junction	109·2
"	Le Cap	100·5
"	St. Vincent-de-Paul	72·1
"	De Sales	54·3
"	Rivière-des-Milles Iles; water, June 23, 1917, 26·7; rail	54·4
"	Terrebonne	59·6
"	Mascouche	62·8
"	Mascouche river; water, July 9, 1917, 26·4; rail	62·2
"	Cabane Ronde	59·2
"	L'Epiphanie	72·7
"	Canadian Northern railway (diamond crossing)	72·7
"	Achigan river; water, July 7, 1917, 24·0; rail	72·4
"	St. Esprit river; water, July 7, 1917, 26·8; rail	68·3
"	L'Assomption river; water, July 11, 1917, 24·2; rail	63·3
"	Vaucluse	76·0

RAIL ELEVATIONS, ST. MARTIN JUNCTION TO THREE RIVERS, QUE.—*Continued.*

(Elevations taken in 1917)

Canadian Pacific Railway—	Lavaltrie	85·3
"	Lanoraie	68·4
"	Paquette	84·4
"	Chaloupe river,; water July 19, 1917, 21·8; rail	56·6
"	Berthier Junction	36·7
"	Bayonne river; water, July 21, 1917, 16·4; rail	37·0
"	Chicot river; water, July 23, 1917, 16·0; rail	37·9
"	St. Cuthbert	37·8
"	St. Barthélemi	33·0
"	Maskinongé river; water, August 8, 1917, 17·6; rail	48·8
"	Maskinongé	48·9
"	Louiseville	42·4
"	Rivière-du-Loup; water, August 10, 1917, 15·9; rail	44·2
"	Yamachiche	33·8
"	Yamachiche river; water, August 11, 1917, 23·6; rail	43·5
"	Pointe-du-Lac	67·7

RAIL ELEVATION, GRENVILLE, QUE. TO PRESCOTT, ONT.

(Elevations taken in 1918)

Canadian Pacific Railway—	Grenville	209·1
Canadian Northern Ry.——	Grenville	174·5
"	Grenville canal; water 128·6; rail	174·8
"	Ottawa river; water, May 29, 1918, 117; rail (centre of bridge)	174·5
"	Hawkesbury	162·4
Grand Trunk Railway———	Hawkesbury	142·9
"	Canadian Northern railway (diamond crossing)	159·9
"	Canadian Pacificrailway, Ottawa-Vaudreuil line (diamond crossing)	263·8
"	Vankleek Hill	296·0
"	Rigaud river; water, June 10, 1918, 194·2; rail	214·8
"	Dalkeith	229·1
"	Glen Sandfield	237·8
"	Glen Robertson	263·1
"	Interprovincial boundary, Ontario-Quebec	244·6
"	Ste. Justine	247·3
"	Canadian Pacific railway, diamond crossing at St. Polycarpe Junction	194·1
"	St. Polycarpe	177·6
Canadian Pacific Railway—	Delisle river; water, June 17, 1918, 157·7; rail	193·8
"	Soulanges, junction switch	200·5
"	Laberge	210·2
"	Baudet river; water, June 17, 1918, 183·2; rail	197·7
"	Bridge End	198·5
"	North Lancaster	186·5
"	Glen Gordon	182·3
"	Williamstown	182·1
"	Raisin river; water, June 27, 1918, 157·6; rail	181·6
"	Glenbrook	176·6
"	Grand Trunk railway, main line (diamond crossing)	191·0
"	Cornwall	182·7
Grand Trunk Railway———	Cornwall	192·9
"	Ottawa & New York railway, diamond crossing at Cornwall Junction	201·7
"	Mille Roches	226·0
"	Moulinette	233·6
"	Wales	237·3
"	Farran Point	242·6
"	Aultsville	247·6
"	Morrisburg	271·1
"	Iroquois	245·1
"	Cardinal	278·8
"	Canadian Pacific railway, Ottawa-Prescott line (under crossing) rail, 284·6; G.T.R. rail	304·6
"	Prescott	310·9
Canadian Pacific Railway—	Prescott	260·3

RAIL ELEVATIONS, IVANHOE TO TORONTO, ONT.

(Elevations taken in 1916 and 1918)

Canadian Pacific Railway—	Ivanhoe	610·3
"	Peterson	561·2
"	Canadian Northern railway, Trenton Maynooth line, diamond crossing at Bonarlaw	598·3
"	Crow river; water, October 16, 1916, 582·9; rail	600·4
"	Tiffin	644·3
"	Havelock	701·0
"	Norwood	671·9
"	Asphodel (flag station)	728·5
"	Indian River	710·3
"	Otonabee	677·1
"	Trent canal; water 632·0; rail	640·6
"	Otonabee river; water, Aug. 22, 1918, 620·5; rail	632·5
"	Peterboro	631·4
"	Grand Trunk railway, Port Hope-Peterboro line (diamond crossing)	636·8
"	Kendry (flag station)	655·9
"	Cavan	645·6
"	Grand Trunk railway, Millbrook-Omemee Junction line (under crossing) rail 839·1; C.P.R. rail	864·7
"	Bethany Junction	855·5
"	Manvers	969·1
"	Pontypool	1,067·1
"	Burketon	1,057·0
"	Brady	1,064·1
"	Myrtle	888·8
"	Grand Trunk railway, Whitby-Lindsay line (overhead crossing) rail 893·0; C.P.R. rail	870·4
"	Dagmar	861·0
"	Glen Major	843·5
"	Claremont	887·0
"	Atha Road	747·5
"	Locust Hill	666·2
"	Little Rouge creek; water, Sept. 17, 1918, 597·7; rail	636·7
"	Rouge creek; water, Sept. 17, 1918, 483·1; rail	526·3
"	Browns Corner	563·4
"	Agincourt	565·5
"	Grand Trunk railway, Lindsay-Scarboro Junction line (under crossing) rail 543·7; C.P.R. rail	570·2
"	Wexford	537·6
"	Canadian Northern railway (under crossing) rail 373·8; C.P.R. rail (eastbound track)	458·0
"	Donlands	448·8
"	Leaside	430·2
"	North Toronto (centre of Yonge street subway)	417·2

RAIL ELEVATIONS, PETERBORO TO PORT HOPE, ONT.

(Elevations taken in 1918)

Grand Trunk Railway—	Peterboro	647·6
"	Canadian Pacific railway, main line (diamond crossing)	636·8
"	Millbrook, Peterboro track	768·6
"	Millbrook, Omemee Junction track	770·0
"	Carmel	908·3
"	Campbellcroft	627·3
"	Perrytown	642·1
"	Quay	475·5
"	Smith creek; water, August 2, 1918, 310·9; rail	328·5
"	Canadian Northern railway, Toronto-Ottawa line (overhead crossing) rail 348·8; G.T.R. rail	304·8
"	Smith creek; water, August 2, 1918, 292·2; rail	298·1
"	Smith creek; water, August 2, 1918, 272·9; rail	280·8
"	Port Hope (centre of Walton street)	273·3
"	Canadian Pacific railway, Lake Ontario Shore line (overhead crossing) rail 294·6; G.T.R. rail	270·0
"	Port Hope Junction	286·8

RAIL ELEVATIONS, MYRTLE TO WHITBY, ONT.

(Elevations taken in 1918)

Grand Trunk Railway—	Myrtle	822·0
"	Brooklin	537·3
"	Canadian Northern railway, Toronto-Ottawa line (diamond crossing)	480·8
Canadian Northern Ry.—	Brooklin	476·2
Grand Trunk Railway—	Canadian Pacific railway, Lake Ontario Shore line (diamond crossing)	299·3
"	Toronto and Eastern (electric) railway, diamond crossing	291·5
"	Whitby (town station)	286·2
"	Whitby Junction	276·3

RAIL ELEVATIONS, NORTH TORONTO TO MIMICO, ONT.

(Elevations taken in 1918)

		FEET
Canadian Pacific Railway—	North Toronto (centre of Yonge street subway)	417·2
"	Grand Trunk railway, Toronto-North Bay line (diamond crossing)	397·6
"	Grand Trunk railway, Toronto-Stratford line (diamond crossing)	396·0
"	Canadian Pacific railway, Toronto-Sudbury line (diamond crossing)	396·0
"	West Toronto	390·4
"	Lambton	398·8
"	Humber river; rail on bridge	399·6
"	Toronto Suburban (electric) railway, under crossing, rail 381·4; C.P.R. rail	402·6
"	Islington	402·7
"	Obico, junction switch	399·6
"	Canpa, junction switch	317·9

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INDEX

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED

Note.—Under "Year of Publication."
1912 refers to Vol. I, No. 2*, "Publications of the Dominion Observatory."
1913 " Vol. I, No. 3, "
1914 " Vol. I, No. 8, "
1915 " Vol. II, No. 1, "
1916 " Vol. III, No. 6, "
1917 " Vol. III, No. 8, "
1918 " Publication No. 1, Geodetic Survey of Canada.
1919 " the present publication.

Place	B.M. Number	Year of Publication	Description	Elevation
			Page.	Page.
Abbotsford, B.C.	28–J	1918	23	43
Abbottsford, Que.	620–B	1918	11	33
Abercorn, Que.	54	1917	282	318
Actonvale, Que.	630–B	1918	9	32
Adamsville, Que.	59	1917	281	317
Agincourt, Ont.	229–G, 230–G	1919	15	23
Ailsa Craig, Ont.	343	1914	220	236
Alameda, Sask.	57–C	1913	69	83
Albert Canyon, B.C.	303–C	1917	270	310
Alcove, Que.	472	1914	218	234
Aldergrove, B.C.	24–J	1916	170	191
Algoma, Ont.	602	1916	156	181
Alix, Alta.	61–F, 62–F	1916	165	187
Allenford, Ont.	292	1913	60	83
Alliston, Ont.	382, 383	1913	64	86
Almonte, Ont.	64–G, 65–G, 66–G	1917	250	293
Alton, Ont.	131–F	1918	17	37
Amherst, N.S.	545–B *to* 548–B	1916	146	173
Andover, N.B.	40–B	1917	277	314
Angers, Que.	858	1919	8	18
Antigonish, N.S.	172–B, 173–B	1913	47	74
Apohaqui, N.B.	115–B	1913	44	73
Appin, Ont.	240	1913	56	81
Apple Hill, Ont.	100	1917	285	320
Ardendale, Ont.	165–G	1917	256	295
Ardrossan, Alta.	55–H	1916	163	186
Argyle, N.S.	457–B	1915	13	30
Arnprior, Ont.	73–G, 74–G, 75–G	1917	250	293
Aroostook, N.B.	41–B	1917	277	314
Artland, Sask.	28–H	1915	20	34
Ashcroft, B.C.	74–J	1918	26	42
Asquith, Sask.	5–H	1915	19	34
Athalmer, B.C.	153–D	1917	265	305
Atwood, Ont.	309	1913	61	83
Auburn, N.S.	487–B	1916	148	175
Aultsville, Ont.	900	1919	12	21
Avondale, N.S.	167–B	1913	47	74
Avonmore, Ont.	103	1917	285	320
Ayers Cliff, Que.	28–A–2, 29	1913	48	75
Aylesbury, Sask.	14–D	1913	72	90
Azilda, Ont.	457	1914	225	238
Baden, Ont.	101–F	1918	15	36
Baker Brook, N.B.	264–B	1917	247	290
Bala, Ont.	408	1913	66	86
Banff, Alta.	240–C, 241–C	1916	167	188
Barons, Alta.	76–D, 77–D	1915	25	38
Barrington, N.S.	444–B	1915	12	29
Barrington Passage, N.S.	446–B	1915	12	29
Barrys Bay, Ont.	523	1915	16	32
Bashaw, Alta.	65–F	1916	165	187

* The bench-mark numbers in this publication (Yukon levelling) follow a series independent of those in the later publications; in order to distinguish them they are printed in italics in the "B.M. Number" column.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Bath, N.B	35–B	1917	276	314
Bayfield, N.S	177–B	1913	48	75
Beamsville, Ont	204	1913	63	85
Beaudette, Minn	16–E	1914	226	239
Beavermouth, B.C	284–C	1917	269	309
Bedford, Que	66	1917	282	318
Bedford, N.S	506–B	1916	144	171
Beecher Falls, Vt	562–B	1916	153	180
Beeton, Ont	379	1913	64	86
Beiseker, Alta	48–F	1916	164	187
Belgrave, Ont	316	1913	61	83
Bellamy, Ont	101–G	1917	252	298
Belle River, Ont	252	1913	57	81
Belleville, N.S	459–B	1915	13	30
Belleville, Ont	156 *to* 157–A–2	1917	288	322
Beloeil, Que	606–B	1918	9	32
Bennett, B. C	*32–R*	1912	23	23
Benton, N.B	18–B	1917	276	313
Berthier Jct., Que	698–B	1919	9	19
Berwick, N.S	488–B	1916	148	175
Bethany Jct., Ont	209–G, 210–G	1919	14	22
Bethune, Sask	9–D	1913	71	90
Bienfait, Sask	61–C	1913	69	88
Biggar, Sask	12–H	1915	20	34
Blackie, Alta	63–D	1915	26	38
Bladworth, Sask	19–D	1914	227	240
Blaine, Wash	19–J	1916	169	190
Blairmore, Alta	103–D	1917	262	304
Blind River, Ont	604, 605	1916	156	181
Bloomfield, N.B	111–B	1913	44	73
Blue River, B.C	124–J, 125–J	1918	28	43
Bluevale, Ont	313	1913	61	83
Blyth, Ont	317	1913	61	83
Boharm, Sask	106–C	1914	229	241
Boiestown, N.B	33–C	1916	151	178
Boissevain, Man	31–C, 32–C	1913	67	87
Bolton, Ont	260	1913	58	82, 86
Bonarlaw, Ont	189–G	1919	13	22
Bordeaux, Que	828	1919	7	18
Bothwell, Ont	243	1913	57	81
Boundary Creek, N.B	128–B	1913	45	73
Bow Island, Alta	178–C, 179–C	1915	23	35
Bowmanville, Ont	177	1913	54	79
Braeburn, Y.T	*57*	1912	27	27
Brant, Alta	65–D	1915	26	38
Brantford, Ont	219, 220	1913	55	80
Breslau, Ont	94–F	1918	14	36
Bridgeburg, Ont	215–A	1913	64	85
Bridgewater, N.S	409–B *to* 411–B	1915	10	28
Brierly Brook, N.S	170–B	1913	47	74
Brighton, Ont	163	1917	288	322
Bristol, N.B	34–B	1917	276	314
Britannia Mills, Que	625–B	1918	9	32
Brockville, Ont	123, 124	1917	286	321
"	105–G, 106–G	1917	252	298
Brome, Que	50	1917	282	318
Bromptonville, Que	648–B	1918	10	33
Brooklin, Ont	923, 924	1919	16	24
Brookport, Que	60	1917	281	317
Bruce, Alta	45–H	1916	162	186
Bruce Mines, Ont	619	1916	156	182
Brucefield, Ont	329	1913	62	84
Brunswick, N.B	6–B	1917	275	313
Brussels, Ont	312	1913	61	83
Buckingham Jct., Que	857	1919	8	18
Bull River, B.C	135–D	1917	264	305
Burdett, Alta	180–C, 181–C	1915	23	35, 36
Burketon, Ont	216–G	1919	14	22
Burlington Jct., Ont	196	1913	55	80
Bury, Que	13–A–2	1913	49	76

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Calabogie, Ont.	139-G	1917	254	299
Calais, Maine	1-B	1917	275	313
Caldwell, Ont.	512	1915	16	32
Caledon, Ont.	265	1913	58	82
"	265	1918	17	37
Calgary, Alta.	50-D, 51-D, 52-D	1915	27	39
"	39-F	1916	163	187
"	217-C, 218-C	1916	166	188
Cambridge, N.S.	490-B	1916	148	175
Campbellcroft, Ont.	918	1919	16	24
Campbellton, N.B.	25-G, 26-G	1916	151	177
Camrose, Alta.	70-F, 71-F	1916	165	187
Canmore, Alta.	235-C	1916	167	188
Canrobert, Que.	622-B	1918	11	33
Canterbury, N.B.	16-B	1917	276	313
Capelton, Que.	26	1913	48	75
Cap St. Ignace, Que.	567-B	1917	247	291
Cap St. Martin, Que.	684-B	1919	9	19
Cardinal, Ont.	910	1919	13	21
Cariboo, Y.T.	*18-R*	1912	24	24
Carievale, Sask.	49-C	1913	68	88
Carleton Place, Ont.	60-G, 61-G, 62-G	1917	249, 250	293
Carmangay, Alta.	73-D, 74-D	1915	25	38
Carnduff, Sask.	50-C	1913	68	88
Caron, Sask.	108-C	1914	229	241
Cartwright, Man.	20-C	1913	67	87
Cascades, Que.	467	1914	218	234
Cataract, Ont.	130-F	1918	16	37
Cavan, Ont.	208-G	1919	14	22
Chamberlain, Sask.	12-D	1913	72	90
Champion, Alta.	71-D	1915	26	38
Chaplin, Sask.	113-C	1914	229	241
Chase, B.C.	342-C	1918	31	45
Chatham, Ont.	246-A, 247, 247-A	1913	57	81
"	373, 247	1914	222	236
Chatham, N.B.	49-G	1916	152	178
Chatsworth, Ont.	283	1913	59	82
Chaudiere, Que.	MCLXXII	1918	‡	34
Chauvin, Alta.	30-H	1915	21	34
Chelsea, Que.	464	1914	218	234
Chesley, Ont.	295, 296	1913	60	83
Chester, N.S.	401-B	1915	10	28
Chesterville, Ont.	107	1917	285	320
Chilliwack, B.C.	34-J, 35-J	1918	24	42
Chin, Alta.	191-C	1915	23	36
Chipman, N.B.	352-B	1914	216	233
Chu Chua, B.C.	98-J	1918	27	43
Clarkson, Ont.	192	1913	55	80
Clarksville, N.S.	520-B, 521-B	1916	145	171
Clayburn, B.C.	29-J	1918	24	42
Clifton, N.S.	531-B	1916	145	172
Clinton, Ont.	320, 321	1913	62	83
Cloverdale, B.C.	20-J, 21-J	1916	169	191
Coaticook, Que.	14, 15, 16	1917	283	319
Coblenz, Sask.	17-H	1915	20	34
Cobourg, Ont.	171	1913	53	79
Cochrane, Alta.	222-C, 223-C	1916	166	188
Colborne, Ont.	166	1917	288	322
Coldbrook, N.S.	491-B	1916	148	175
Coldwater, Ont.	399-A	1913	65	86
Coleman, Alta.	105-D	1917	262	304
Collins Bay, Ont.	144	1917	287	321
Compton, Que.	10	1917	283	319
Condie, Sask.	5-D	1913	71	90
Conn Mills, N.S.	139-B	1913	46	74
Cooking Lake, Alta.	53-H	1916	163	186
Cookshire, Que.	10-A-3, 11-A	1913	49	76
Copetown, Ont.	216-A	1913	55	80
Corbetton, Ont.	273	1913	59	82
Corbyville, Ont.	185-G	1917	257	301

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Cornwall, Ont.	489, 490, 491	1914	219	235
"	893, 894	1919	12	20, 21
Corunna, Ont.	361	1914	221	236
Coteau Jct., Que.	90	1917	284	320
Côte-des-Neiges, Que.	815, 816, 817	1918	13	35
Courtright, Ont.	363	1914	222	236
Coutts, Alta.	216-C†	1915	25	37
Cowley, Alta.	97-D	1917	262	304
Craighurst, Ont.	392	1913	65	86
Craik, Sask.	16-D	1913	72	90
Cranbrook, B.C.	172-D *to* 174-D	1917	266	307
Creston, B.C.	195-D, 196-D	1917	268	307
Crookston, Ont.	179-G	1917	257	296
Crowsnest, B.C.	109-D	1917	263	304
Crysler, Ont.	496	1914	220	235
Crystal City, Man.	16-C	1913	67	87
Dalhousie Mills, Ont.	95	1917	285	320
Dalkeith, Ont.	873, 874	1919	11	20
Danby, Que.	633-B	1918	10	33
Danville, Que.	679-B	1918	12	43
Dauntless, Alta.	171-C	1915	22	35
Davidson, Sask.	18-D	1914	227	240
Dawson, Y.T.	*223, 224*	1912	34	34
Dean Lake, Ont.	609	1916	156	182
Debec, N.B.	20-B	1917	276	313
Delburne, Alta.	59-F	1916	165	187
Deloraine, Man.	36-C	1913	68	88
Delson, Que.	593-B, 594-B	1918	8	32
Denfield, Ont.	338	1913	62	84
Denmark, N.S.	149-B	1913	46	74
Depot Harbour, Ont.	566, 567	1915	13	31
Derby Jct., N.B.	47-G-2	1916	152	178
Derby Line, Vt.	33-A	1913	49	75
De Sales, Que.	687-B, 633-B	1919	9	19
Desbarats, Ont.	622	1916	157	182
Devlin, Ont.	27-E	1914	226	239
DeWinton, Alta.	57-D	1915	26	38
Dinant, Alta.	73-F	1916	165	187
Disley, Sask.	8-D	1913	71	90
Doaktown, N.B.	37-G	1916	151	178
Dobbinton, Ont.	294	1913	60	83
Dorchester, N.B.	DCCCLXXXIX, *etc.*	1916	‡	174
Dorenlee, Alta.	66-F	1916	165	187
Dosquet, Que.	657-B	1918	11	34
Drayton, Ont.	123-F	1918	16	37
Dresden, Ont.	370	1914	222	236
Drinkwater, Sask.	91-C	1913	70	89
Duck, B. C.	348-C	1918	31	45
Duck Lake, Sask.	42-D	1914	228	240
Dundalk, Ont.	274	1913	59	82
Dundas, Ont.	215	1913	55	80
Dundurn, Sask.	25-D	1914	227	240
Dunmore, Alta.	165-C	1915	22	35
Eastman, Que.	44	1917	281	317
East Pubnico, N.S.	453-B	1915	13	29
Eastray, Que.	44	1917	281	317
East Templeton, Que.	860, 861	1919	8	18
Eastwood, Ont.	225	1913	55	80
Echo Bay, Ont.	626	1916	157	182
Edgerton, Alta.	33-H	1915	21	34
Edmonton, Alta.	58-H *to* 61-H	1916	163	186
Edmundston, N.B.	58-B, 59-B, 60-B	1917	278	314
Edson, Alta.	81-H, 82-H	1917	272	311
Eganville, Ont.	514	1915	16	32
Elmwood, Ont.	297	1913	60	83

† Also bench-mark in international boundary monument.
‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Elora, Ont.	117-F, 118-F	1918	16	37
Elva, Man.	44-C	1913	68	88
Embrun, Ont.	498	1914	220	235
Emerson, Man.	3-C	1913	66	87
Emo, Ont.	23-E, 24-E	1914	226	239
Enlaugra, Que.	51	1917	282	318
Ensign, Alta.	66-D	1915	26	38
Erin, Ont.	129-F	1918	16	37
Ernestown, Ont.	146	1917	287	321
Ernfold, Sask.	115-C	1914	229	241
Estevan, Sask.	62-C, 63-C	1913	69	88
Eureka, Y.T.	*187*	1912	33	33
Exeter, Ont.	332, 333	1913	62	84
Fairville, N.B.	96-B	1917	280	316
Farnham, Que.	62	1917	281	317
"	63, 64	1917	282	318
"	623-B, 62	1918	11	33
Farran Point, Ont.	899	1919	12	21
Fassett, Que.	847	1919	8	18
Fergus, Ont.	119-F, 120-F	1918	16	37
Ferintosh, Alta.	67-F	1916	165	187
Fernie, B.C.	121-D *to* 123-D	1917	263	305
Field, B.C.	260-C	1916	168	189
Finch, Ont.	105	1917	285	320
"	495	1914	219	235
Findlater, Sask.	11-D	1913	72	90
Flesherton, Ont.	277	1913	59	82
Forest, Ont.	351	1914	221	236
Fort Erie, Ont.	215-A	1913	64	85
Fort Frances, Ont.	29-E, 30-E	1914	226	239
Fort William, Ont.	90-E *to* 92-E	1916	161	184
Foster, Que.	47	1917	281	317
Frank, Alta.	102-D	1917	262	304
Franz, Ont.	708	1917	261	303
French Village, N.S.	393-B	1915	9	28
Frobisher, Sask.	58-C	1913	69	88
Fulford, Que.	56	1917	281	317
Gainsborough, Sask.	47-C	1913	68	88
Galt, Ont.	81-F *to* 82-F-2.	1918	14	36
Girvin, Sask.	17-D	1913	72	90
Glacier, B.C.	294-C	1917	270	309
Glacier, Y.T.	*266*	1912	36	36
Glencoe, Ont.	241, 241-A	1913	56	81
Glen Ewen, Sask.	52-C	1913	68	88
Glen Robertson, Ont.	876, 877	1919	11	20
Glentay, Ont.	117-G	1917	253	295
Goderich, Ont.	325, 326, 327	1913	62	83, 84
Godfrey, Ont.	150-G	1917	255	300
Golden, B.C.	273-C	1917	269	309
Golden Lake, Ont.	515	1915	16	32
Goodlands, Man.	38-C	1913	68	88
Gracefield, Que.	484	1914	219	234
Graceton, Minn.	14-E	1914	226	239
Grafton, Ont.	168	1913	53	79
Grainger, Alta.	50-F	1916	164	187
Grand Coulée, Sask.	101-C	1913	71	89
Grand Falls, N.B.	46-B	1917	277	314
Grand Ligne, Que.	78	1917	280	317
Grand Pré, N.S.	498-B	1916	149	175
Grandora, Sask.	3-H	1915	19	34
Grassy Lake, Alta.	182-C, 183-C	1915	23	36
Green River, N.B.	54-B	1917	277	314
Green Valley, Ont.	97	1917	285	320
Grenville, Que.	842, 843	1919	7	18
"	865, 866	1919	10	20
Gretna, Man.	4-C	1913	66	87

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Grimsby, Ont.	203	1913	63	85
Guelph, Ont.	90–F *to* 92–F	1918	14	36
Guelph Jct., Ont.	88–F, 89–F	1918	14	36
Gull Lake, Sask.	136–C	1914	230	241
Hague, Sask.	38–D	1914	228	240
Halbrite, Sask.	73–C	1913	69	89
Halifax, N.S.	386–B, 387–B	1915	9	28
"	386–B, 387–B	1916	144	171
Hallock, Minn.	2–C	1913	66	87
Hamilton, Ont.	198, 199, 200	1913	63	85
Hampton, N.B.	109–B	1913	44	73
Hanley, Sask.	23–D	1914	227	240
Hanover, Ont.	298, 299	1913	60	83
Hantsport, N.S.	500–B	1916	149	176
Harlaka Jct., Que.	219–B	1913	52	77
Harrisburg, Ont.	77–F	1918	14	36
Harriston, Ont.	303, 304	1913	61	83
Harrowsmith, Ont.	154–G	1917	255	300
Hartland, N.B.	31–B	1917	276	313
Hatton, Sask.	151–C	1915	21	35
Havelock, Ont.	193–G–2	1919	13	22
Hawkesbury, Ont.	867 *to* 869	1919	11	20
Hawthorne, Ont.	502	1914	220	235
Heath, Alta.	34–H	1915	21	34
Henfryn, Ont.	310	1913	61	83
Herbert, Sask.	118–C	1914	230	241
Heron Bay, Ont.	742, 742–A	1918	19	39
Hespeler, Ont.	86–F	1918	14	36
Hillhurst, Que.	13	1917	283	319
Hillsburgh, Ont.	128–F	1918	16	37
Holden, Alta.	46–H	1916	163	186
Holland Centre, Ont.	281	1913	59	82
Holmesville, Ont.	322	1913	62	83
Holmfield, Man.	22–C	1913	67	87
Hope, B.C.	42–J, 43–J	1918	24	42
Howick Jct., Que.	87	1917	284	320
Hubbards, N.S.	397–B	1915	9	28
Hull, Que.	459, 460	1914	217	234
Humes, Y.T.	*132*	1912	31	31
Huntingdon, B.C.	26–J, 27–J	1916	170	191
Hyde Park Jct., Ont.	341	1913	63	84
Iberville, Que.	74	1917	280	317
Ilderton, Ont.	339	1913	63	84
Indian River, Ont.	198–G	1919	14	22
Indian River, Y.T.	*205*	1912	33	33
Ingersoll, Ont.	229, 230	1913	56	80
Inkerman, Ont.	110	1917	285	320
Irma, Alta.	39–H	1916	162	185
Iroquois, Ont.	907, 908	1919	13	21
Irvine, Alta.	159–C, 160–C	1915	22	35
Islington, Ont.	243–G, 244–G	1919	17	25
Ivanhoe, Ont.	179–G	1917	257	296
Jackfish, Ont.	757	1918	19	39
Jaffray, B.C.	131–D, 132–D	1917	264	305
James River, N.S.	169–B	1913	47	74
Jasper, Alta.	104–H	1917	274	312
Jasper, Ont.	97–G	1917	252	298
Jeannette, Ont.	249–A	1913	57	81
Jordan, Ont.	205	1913	63	85
Juniata, Sask.	6–H	1915	19	34
Kakabeka Falls, Ont.	85–E	1916	161	184
Kamloops, B.C.	353–C *to* 355–C	1918	31	45
Kamloops Jct., B.C.	87–J	1918	26	43
Kazabazua, Que.	479	1914	218	234
Kearney, Ont.	552	1915	14	31
Keewatin, Ont.	34–F	1915	19	33

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Kempton, Ont.	113	1917	286	320
Kemptville, Ont.	113-A	1913	52	78
Kenaston, Sask.	21-D	1914	227	240
Kennetcook, N.S.	523-B, 524-B	1916	145	171
Kenora, Ont.	36-F, 37-F, 38-F	1915	19	33
Kentville, N.S.	492-B *to* 494-B	1916	148	175
Kilburn, N.B.	37-B	1917	277	314
Killaloe, Ont.	518, 519	1915	16	32
Killarney, Man.	25-C	1913	67	87
Kingsey, Que.	677-B	1918	12	44
Kingston, N.S.	486-B	1916	148	175
Kingston, Ont.	139, 141, 141-A, 142	1917	287	321
Kipp, Alta.	81-D	1915	25	38
Kippen, Ont.	330	1913	62	84
Kirkcaldy, Alta.	70-D	1915	26	38
Kirk Ferry, Que.	465, 466	1914	218	234
Kitchener, Ont.	95-F *to* 97-F	1918	15	36
Kleinburg, Ont.	258	1913	58	82
Knowlton, Que.	49	1917	282	318
Komoka, Ont.	237-A	1913	56	80
Kootenay Landing, B.C.	204-D, 205-D	1917	268	308
Lac Baker, N.B.	267-B	1917	247	290
Lachute, Que.	838	1919	7	18
Lacolle, Que.	583-B	1918	8	32
Lake Louise, Alta.	248-C, 249-C	1916	167	189
Lambton, Ont.	242-G	1919	17	25
Landis, Sask.	16-H	1915	20	34
Lanoraie, Que.	697-B	1919	9	19
Lansdowne, Ont.	130, 131	1917	286	321
Laprairie, Que.	596-B	1918	8	32
Lavant, Ont.	132-G	1917	254	299
Leaside, Ont.	233-G	1919	15	23
Le Cap, Que.	684-B	1919	9	19
Leckford, Sask.	41-D	1914	228	240
Leney, Sask.	8-H	1915	19	34
Lennoxville, Que.	6	1917	283	319
L'Epiphanie, Que.	693-B	1919	9	19
Lepreau, N.B.	89-B	1917	279	316
Lethbridge, Alta.	196-C *to* 200-C	1915	24	36
" "	83-D	1915	25	38
Lévis, Que.	221-B, 222-B	1913	52	77
"	222-B	1916	153	179
L'Islet, Que.	568-B	1917	248	291
Listowel, Ont.	307, 308	1913	61	83
Little River, Y.T.	*34*	1912	26	26
Liverpool, N.S.	418-B, 419-B, 420-B	1915	11	29
Locust Hill, Ont.	226-G	1919	15	23
Londesborough, Ont.	318	1913	61	83
London, Ont.	235, 236	1913	56	80
Londonderry, N.S.	CMLXXIX	1916	‡	172
Longwood, Ont.	239-A	1913	56	81
Louiseville, Que.	705-B, 706-B	1919	10	19
Lousana, Alta.	58-F	1916	165	187
Low, Que.	476	1914	218	234
Lower Argyle, N.S.	455-B	1915	13	30
Lower East Pubnico, N.S.	452-B	1915	12	29
Lucan, Ont.	114-F	1918	15	36
Lucan Crossing, Ont.	337	1913	62	84
" "	337	1918	15	36
Lucerne, B.C.	111-H	1918	22	41
Lumsden, Sask.	7-D	1913	71	90
Lyn, Ont.	125	1917	286	321
Lynden, Ont.	217	1913	55	80
Lyon Brook, N.S.	156-B	1913	47	74
Lyster, Que.	660-B	1918	11	34
Lytton, B.C.	62-J, 63-J	1918	25	42
Maccan, N.S.	CMXVI	1916	‡	173
Macleod, Alta.	87-D, 88-D	1917	262	304
Macoun, Sask.	69-C	1913	69	89

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Madawaska, Ont.	530, 531	1915	15	32
Madoc Jct., Ont.	182–G	1917	257	301
Magog, Que.	40, 41, 41–A	1917	281	317
Maitland, Ont.	121	1917	286	320
Malagash, N.S.	144–B	1913	46	74
Mallorytown, Ont.	128	1917	286	321
Manitou, Man.	11C, 12–C	1913	66	87
Maple Creek, Sask.	145–C, 146–C	1914	231	241
Markdale, Ont.	279	1913	59	82
Marysville, Ont.	152	1917	288	321
Mascouche, Que.	689–B	1919	9	19
Maskinongé, Que.	703–B, 704–B	1919	10	19
Massawippi, Que.	28–A	1913	48	75
Masson, Que.	857	1919	8	18
Massey, Ont.	590	1916	155	181
Mather, Man.	17–C	1913	67	87
Matsqui, B.C.	30–J	1918	24	42
McAdam, N.B.	11–B	1917	275	313
McBride, B.C.	131–H	1918	23	41
McGivney Jct., N.B.	333–B	1914	215	233
Meadowville, N.S.	153–B	1913	46	74
Medicine Hat, Alta.	167–C, 168–C, 169–C	1915	22	35
Medora, Man.	40–C	1913	68	88
Medway, N.S.	415–B	1915	10	28
Megantic, Que.	21–A–2, 22–A	1913	50	76
Melancthon, Ont.	271–A, 272	1913	59	82
Melita, Man.	42–C, 43–C	1913	68	88
Melville, Ont.	132–F	1918	17	37
Memramcook, N.B.	549–B	1916	146	174
Merigomish, N.S.	164–B	1913	47	74
Merrickville, Ont.	84–G	1917	251	295
Merritton, Ont.	209	1913	63	85
Michel, B.C.	114–D	1917	263	304
Michipicoten, Ont.	698	1917	261	303
Midale, Sask.	71–C	1913	69	89
Middleton, N.S.	482–B, 483–B	1916	148	175
Midhurst, Ont.	390	1913	65	86
Midnapore, Alta.	54–D	1915	27	39
Milan, Que.	18–A–2	1913	50	76
Milestone, Sask.	85–C	1913	70	89
Milk River, Alta.	213–C, 214–C	1915	25	37
Millbrook, Ont.	915, 916	1919	15	24
Mille Roches, Ont.	895	1919	12	21
Millerton, N.B.	47–G	1916	152	178
Mimico, Ont.	245–G	1919	17	25
Mine Centre, Ont.	42–E	1916	158	183
Minto, Y.T.	*106*	1912	30	30
Mirror, Alta.	63–F	1916	165	187
Mission, B.C.	30–J	1918	24	42
Molson, Man.	10–F	1915	17	33
Monarch, Alta.	84–D	1917	261	304
Monckland, Ont.	102	1917	285	320
Moncton, N.B.	132–B, 133–B, 134–B	1913	45	73
"	373–B, 374–B, 132–B	1914	217	233
"	132–B	1916	146	174
Monk, Que.	385–B	1917	245	289
Montague, Y.T.	*69*	1912	28	28
Mont Carmel, Que.	28–G	1917	248	292
Montebello, Que.	848, 849	1919	8	18
Montmagny, Que.	566–B	1917	247	291
Montreal, Que.	807 *to* 825	1918	13, 14	35
Montreal West, Que.	811 *to* 813	1918	13	35
Mooretown, Ont.	362	1914	221	236
Moosejaw, Sask.	94–C, 95–C, 96–C	1913	71	89
"	103–C	1914	229	241
Morden, Man.	7–C, 8–C	1913	66	87
Morrisburg, Ont.	904, 905	1919	12	21
Morse, Sask.	116–C, 117–C	1914	229	241
Mortlach, Sask.	110–C	1914	229	241

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Mountain, Ont.	111	1917	285	320
Moyie, B.C.	181–D	1917	267	307
Mulgrave, N.S.	185–B	1913	48	75
Muniac, N.B.	37–B	1917	277	314
Murrayville, B.C.	23–J	1916	170	191
Musquash, N.B.	91–B, 92–B	1917	279	316
Myrtle, Ont.	219–G	1919	14	23
Mystic, Que.	65	1917	282	318
Nairn, Ont.	579, 580	1916	154	181
Napadogan, N.B.	323–B, 324–B	1914	215	232
Napanee, Ont.	149 *to* 150–A–2	1917	287	321
Napierville, Que.	586–B, 587–B	1918	8	32
Napinka, Man.	41–C	1913	68	88
Nappan, N.S.	CMXIX	1916	‡	173
Nauwigewauk, N.B.	107–B	1913	44	73
Nelson Jct., N.B.	47–G–2	1916	152	178
Newbury, Ont.	242	1913	56	81
Newcastle, Ont.	176	1913	53	79
New Dayton, Alta.	206–C, 207–C	1915	24	36
New Germany, N.S.	469–B–2	1916	147	175
New Glasgow, N.S.	160–B	1913	47	74
New Hamburg, Ont.	102–F, 103–F	1918	15	36
New Norway, Alta.	68–F	1916	165	187
New Westminster, B.C.	9–J *to* 13–J	1916	169	190
Nictaux, N.S.	480–B	1916	148	175
Ninga, Man.	29–C	1913	67	87
Nipigon, Ont.	785	1918	21	40
Nobleford, Alta.	79–D	1915	25	38
Nordenskiöld, Y.T.	*47*	1912	27	27
Northfield, Ont.	494	1914	219	235
North Lake, Ont.	106–E	1916	162	185
North Lancaster, Ont.	887	1919	12	20
North Portal, Sask.	†	1913	88	88
Northwood, Ont.	245	1913	57	81
Norton, N.B.	113–B	1913	44	73
Norton Mills, Vermont	23, 24, 25	1917	284	319
Norwood, Ont.	196–G	1919	13	22
Notch Hill, B.C.	339–C	1918	31	45
Notre-Dame-du-Lac, Que.	64–B	1917	278	314
Oak Bay, N.B.	4–B	1917	275	313
Oakville, Ont.	193	1913	55	80
Oban, Sask.	14–H	1915	20	34
Okotoks, Alta.	60–D	1915	26	38
Orangeville, Ont.	267	1913	58	82
Osgoode, Ont.	117–A, 118–A	1913	52	78
Oshawa, Ont.	178–A, 179–A, 179	1913	54	79
Osler, Sask.	36–D	1914	228	240
Ottawa, Ont.	124–A, 125–A	1913	53	78
"	503, 504, 124–A	1914	220	235
Owen Sound, Ont.	286, 287, 288	1913	60	82
Oxbow, Sask.	55–C	1913	69	88
Oxford, Ont.	114	1917	286	320
Oxford, N.S.	136–B	1913	46	74
Oxford Jct., N.S.	135–B	1913	45	74
" "	135–B	1916	146	173
Painsec, N.B.	MDXLIII	1916	‡	174
Pakenham, Ont.	68–G, 69–G	1917	250	293
Palgrave, Ont.	376	1913	64	86
Palmerston, Ont.	305	1913	61	83
"	305	1918	16	37
Papineauville, Que.	850, 850–A	1919	8	18
Paquette, Que.	557–B	1916	153	180
Paris, Ont.	222	1913	55	80
Parkbeg, Sask.	111–C	1914	229	241
Park Head Jct., Ont.	291	1913	60	83
Parkhill, Ont.	346	1914	221	236

† International boundary monument. ‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS, AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Parry Sound, Ont.	419, 420	1914	223	237
Pasqua, Sask.	93–C	1913	71	89
Pelly, Y.T.	*118, 119*	1912	30	30
Pense, Sask.	99–C	1913	71	89
Perth, Ont.	112–G *to* 115–G	1917	253	295
Perth, N.B.	39–B	1917	277	314
Peterboro, Ont.	202–G *to* 205–G	1919	14	22
Petitcodiac, N.B.	123–B	1913	45	73
Piapot, Sask.	141–C	1914	231	241
Pickering, Ont.	180–A–2	1913	54	79
Piedmont, N.S.	165–B	1913	47	74
Pierson, Man.	46–C	1913	68	88
Pike Creek, Ont.	253	1913	57	81
Pilot Mound, Man.	15–C	1913	67	87
Pincher, Alta.	94–D	1917	262	304
Pinewood, Ont.	20–E	1914	226	239
Pinto, Sask.	67–C	1913	69	88
Plaster Rock, N.B.	301–B, 302–B	1914	213	232
Plessisville, Que.	665–B, 666–B	1918	12	34
Pointe-du-Lac, Que.	711–B	1919	10	19
Pointe Gatineau, Que.	863, 864	1919	9	18
Pomquet, N.S.	76–B	1913	48	74
Pontypool, Ont.	213–G	1919	14	22
Portal, North Dakota	†	1913	88	88
Port Arthur, Ont.	93–E *to* 95–E	1916	161	184
"	93–E	1918	21	40
Port Clyde, N.S.	442–B	1915	12	29
Port Colborne, Ont.	135–F *to* 137–F	1918	17	38
Port Dalhousie, Ont.	133–F, 134–F	1918	17	38
Porthill, Idaho	198–D	1917	268	307
Port Hope, Ont.	172, 172–A, 173			
	920, 921	1919	16	24
Port Robinson, Ont.	212	1913	63	85
Port Saxon, N.S.	441–B	1915	12	29
Port Union, Ont.	182	1913	54	79
Port Whitby, Ont.	927	1919	16	24
Prescott, Ont.	118, 119, 913, 914	1919	13	21
Preston, Ont.	83–F, 84–F	1918	14	36
Prince Albert, Sask.	47–D, 48–D, 49–D	1914	228	240
Princeton, Ont.	224	1913	55	80
Princeville, Que.	668–B	1918	12	34
Pubnico, N.S.	454–B	1915	13	30
Quarryville, N.B.	45–G	1916	152	178
Rainy River, Ont.	17–E	1914	226	239
Reford, Sask.	18–H	1915	20	34
Regina, Sask.	1–D, 2–D, 3–D	1913	71	90
Renfrew, Ont.	505, 506, 507	1915	17	32
"	505	1917	251, 254	294, 299
Resplendent, B.C.	117–H, 153–J	1918	29	44
Revelstoke, B.C.	311–C *to* 314–C	1917	271	310
Richford, Vt.	55	1917	282	318
Richmond, Que.	639–B, 640–B	1918	10	33
River Beaudette, Que.	DLXXVII	1917	‡	322
River Glade, N.B.	125–B	1913	45	73
Rivière-du-Loup, Que.	76–B, 77–B, 78–B	1917	279	315
Rivière Ouelle Jct., Que.	MCXXXVII	1917	‡	292
Roche-Percée, Sask.	65–C	1913	69	88
Rock Island, Que.	33–A	1913	49	75
Romford, Ont.	452	1914	224	238
Roosevelt, Minn.	13–E	1914	226	239
Rosedale, B.C.	36–J	1918	24	42
Rose Point, Ont.	565	1915	13	31
Rossport, Ont.	768	1918	20	40
Rosthern, Sask.	40–D	1914	228	240
Rothesay, N.B.	103–B, 104–B	1913	44	73
Rouleau, Sask.	88–C, 89–C	1913	70	89

† International boundary monument. ‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS, AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Rouse Point, N.Y.	581–B	1918	8	32
Rush Lake, Sask.	120–C	1914	230	241
Russell, Ont.	499	1914	220	235
Ryley, Alta.	47–H, 48–H	1916	163	186
Sable River, N.S.	427–B	1915	11	29
Sackville, N.B.	MCCCCXXXVI,etc.	1916	‡	174
Salmon Arm, B.C.	335–C	1918	30	45
Sandstone, Alta.	58–D	1915	26	38
Sarnia, Ont.	357, 358, 359, 360	1914	221	236
Saskatoon, Sask.	29–D *to* 33–D	1914	227, 228	240
Sault Ste. Marie, Ont.	632, 633	1916	157	182
Sault Ste. Marie, Mich.	636	1916	157	182
Savona, B.C.	81–J	1918	26	43
Sawyerville, Que.	552–B	1916	153	180
Schreiber, Ont.	763, 764	1918	20	40
Scotia Jct., Ont.	553	1915	14	31
Scotstown, Que.	16–A–2	1913	49	76
Scott, Sask.	19–H	1915	20	34
Shag Harbour, N.S.	449–B	1915	12	29
Shallow Lake, Ont.	290	1913	60	83
Shannonville, Ont.	154	1917	288	321
Sharbot Lake, Ont.	124–G	1917	253	295
Shelburne, N.S.	433–B *to* 436–B	1915	11, 12	29
Shelburne, Ont.	271	1913	59	82
Sherbrooke, Que.	1, 2, 3	1917	283	319
"	35, 36	1917	281	317
"	3	1918	10	33
Sicamous, B.C.	330–C	1918	30	45
Siegas, N.B.	51–B	1917	277	314
Sirdar, B.C.	203–D	1917	268	308
Slate River, Ont.	87–E	1916	161	184
Smiths Falls, Ont.	88–G, 89–G			
	107–G, 108–G	1917	251 to 253	295
South Durham, Que.	635–B	1918	10	33
South Maitland, N.S.	528–B, 529–B	1916	145	172
South Stukely, Que.	45	1917	281	317
Spence Bridge, B.C.	67–J, 68–J	1918	25	42
Spillimacheen, B.C.	159–D	1917	265	306
Sprague, Man.	10–E	1914	225	239
Springfield, N.S.	472–B	1916	147	175
Springhill, Que.	19–A–2, 20–A	1913	50	76
Springhill Jct., N.S.	CMX	1916	‡	173
Sprucedale, Ont.	556	1915	14	31
Sprucegrove, Alta.	64–H	1917	271	311
Stanbridge, Que.	67	1917	282	318
Stanley, Ont.	86–E	1916	161	184
Stanstead, Que.	34	1913	49	75
Steele, B.C.	138–D	1917	264	305
Steelton, Ont.	634, 635	1916	157	182
Stellarton, N.S.	MCCC	1913	‡	75
Stephen, Minnesota	1–C	1913	66	87
Stevens, Y.T.	*148*	1912	31	31
Stewart Crossing, Y.T.	*162, 163*	1912	32	32
Stickney, N.B.	32–B	1917	276	313
Stirling, Alta.	203–C, 204–C	1915	24	36
Stittville, Ont.	55–G	1917	249	293
Stoney Creek, Ont.	201	1913	63	85
Stoney Point, Ont.	250	1913	57	81
Stonyplain, Alta.	65–H	1917	271	311
Stottsville, Que.	79	1917	280	317
Stratford, Ont.	106–F *to* 108–F	1918	15	36
Sudbury, Ont.	454, 454–A	1914	225	238
"	567–A	1916	154	181
Sumas, Wash.	26–J, 27–J	1916	170	191
Sussex, N.B.	117–B	1913	44	73
Sutton, Que.	52	1917	282	318
Swalwell, Alta.	51–F	1916	164	187
Sweetgrass, Montana	216–C †	1915	25	37
Swift Current, Sask.	126–C, 127–C	1914	230	241

‡ Refer to Public Works Dept. † Also bench-mark in international boundary monument.

ALPHABETICAL LIST OF CITIES, TOWNS, AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M Number	Year of Publication	Description	Elevation
			Page	Page
St. Agapit, Que	653–B *to* 655–B	1918	11	34
St.Alexandre, Que. (Kamouraska Co.)	MCLI	1917	‡	292
Ste. Anne, Que. (Kamouraska Co.)	MXCIX	1917	‡	292
St. Anselme, Que	214–B	1913	52	77
St. Armand, Que	68, 69, 70	1917	282	318
St. Barthélemi, Que	702–B	1919	10	19
St. Bazile, Que. (Chambly Co.)	604–B	1918	9	32
St. Bruno, Que. (Chambly Co.)	602–B	1918	9	32
St. Catharines, Ont	207,208	1913	63	85
St. Charles Jct., Que	MCXXXI	1917	‡	291
St. Cuthbert, Que	700–B	1919	10	19
St. Edouard, Que. (Napierville Co.)	589–B	1918	8	32
St. Evariste, Que	195–B, 196–B	1913	51	77
St. George, N.B	83–B	1917	279	316
Ste. Hénédine, Que	212–B	1913	52	77
St. Henri, Que (Levis County)	216–B	1913	52	77
St. Hilaire, N.B	262–B	1917	247	290
St. Hilaire, Que. (Rouville Co.)	607–B	1918	9	32
St. Honoré, Que (Temiscouata Co.)	70–B	1917	278	314
St. Hubert, Que	600–B	1918	9	32
St. Hyacinthe, Que	611–B *to* 613–B	1918	9	32
"	615–B	1918	10	33
St. Jean Port Joli, Que	MCVI	1917	‡	291
St. John, N.B	97–B *to* 100–B	1917	280	316
St. Johns, Que	75, 76	1917	280	317
St. Joseph-de-Lévis, Que	220–B	1913	52	77
Ste. Julie, Que. (Megantic Co.)	662 B	1918	11	34
Ste. Justine, Que. (Vaudreuil Co.)	879	1919	11	20
St. Lambert, Que	597–B–2, 598–B	1918	9	32
St. Leonard, N.B	50–B	1917	277	314
St. Liboire, Que	626–B	1918	9	32
St. Louis, Que. (Beauharnois Co.)	88	1917	284	320
Ste. Madeleine, Que	609–B	1918	9	32
Ste. Malachie, Que	227–B	1917	244	289
St. Malo, Que. (Compton County)	555–B	1916	153	180
St. Margaret, N.S	394–B	1915	9	28
St. Martin Jct., Que	829	1919	7	18
Ste. Marie, Que. (Beauce Co)	209–B	1913	51	77
St. Marys, Ont	110–F, 111–F	1918	15	37
St. Pacôme, Que	MXCVI	1917	‡	292
St. Paschal, Que	MCXLVI	1917	‡	292
St. Philippe-de-Neri, Que	27–G	1917	248	292
St. Pie, Que. (Bagot County)	618–B	1918	11	33
St. Pierre, Que. (Montmagny Co.)	565–B	1917	247	291
St. Polycarpe, Que	882	1919	11	20
St. Polycarpe Jct., Que	92, 881	1919	11	20
Ste. Rosalie Jct., Que	614–B	1918	9	32
Ste. Rose, Que. (Laval Co.)	831	1919	7	18
Ste. Rose, Que. (Temiscouata Co)	62–B	1917	278	314
Ste. Rose-de-Lima, Que	860, 861	1919	8	18
Ste. Scholastique, Que	835–A, 836	1919	7	18
St. Stephen, N.B	2–B, 3–B	1917	275	313
St. Télesphore, Que	884	1919	11	20
Ste. Thérèse, Que	832	1919	7	18
St. Vallier, Que	MCXXV	1917	‡	291
St. Vincent-de-Paul, Que	686–B	1919	9	19
Taber, Alta	186–C, 187–C	1915	23	36
Taft, B.C	323–C	1918	30	44
Takhini, Y.T	*20, 21*	1912	25	25
Tako, Sask	20–H	1915	20	34
Tara, Ont	293	1913	60	83
Tatamagouche, N.S	147–B	1913	46	74
Terrebonne, Que	687–B	1919	9	19

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Continued.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Thamesville, Ont.	243–A	1913	57	81
Thedford, Ont.	349	1914	221	236
Thornhill, Man.	9–C	1913	66	87
Thorold, Ont.	210, 211	1913	63	85
Three Hills, Alta.	53–F	1916	164	187
Three Rivers, Que.	713–B *to* 716–B	1919	10	19
Thurso, Que.	854	1919	8	18
Tichborne, Ont.	146–G	1917	255	300
Tofield, Alta.	50–H, 51–H	1916	163	186
Tompkins, Sask.	138–C	1914	231	241
Toronto, Ont.	185 *to* 189	1913	54	79
"	234–G *to* 241–G	1919	15, 16, 17	23, 25
Tottenham, Ont.	377–A	1913	64	86
Trenton, Ont.	161	1917	288	322
Tring Jct., Que.	204–B	1913	51	77
Trochu, Alta.	55–F	1916	164	187
Truro, N.S.	534–B *to* 537–B	1916	146	172
Tupperville, Ont.	369	1914	222	236
Tusket, N.S.	460–B	1915	13	30
Tweed, Ont.	174–G *to* 176–G	1917	256	296
Unity, Sask.	22–H	1915	20	34
Upper Woods Harbour, N.S.	451–B	1915	12	29
Upton, Que.	627–B, 628–B	1918	9	32
Utopia, Ont.	387	1913	65	86
Valleyfield, Que.	89	1917	284	320
Valley Jct., Que.	207–B	1913	51	77
Van Buren, Maine	50–B	1917	277	314
Vanceboro, Maine	12–B, 13–B	1917	275	313
Vancouver, B.C.	1–J *to* 5–J	1916	168	190
Vankleek Hill, Ont.	871	1919	11	20
Vera, Sask.	23–H	1915	20	34
Verona, Ont.	152–G	1917	255	300
Versailles, Que.	72	1917	280	317
Victoriaville, Que.	670–B *to* 672–B	1918	12	34
Viking, Alta.	43–H	1916	162	185
Vulcan, Alta.	68–D, 69–D	1915	26	38
Wabamun, Alta.	69–H	1917	272	311
Wainwright, Alta.	36–H	1915	21	34
Wakefield, Que.	469, 470	1914	218	234
Wales, Ont.	897	1919	12	21
Walkerville, Ont.	255	1913	57	81
Wallaceburg, Ont.	367	1914	222	236
Walsh, Alta.	155–C	1915	22	35
Warman, Sask.	35–D	1914	228	240
Warner, Alta.	209–C, 210–C	1915	24	36, 37
Warroad, Minn.	12–E	1914	226	239
Warwick, Que.	674–B, 675–B	1918	12	34
Waterloo, Ont.	98–F, 99–F	1918	15	36
Waterville, N.S.	489–B	1916	148	175
Waterville, Que.	9	1917	283	319
Watt, N.B.	8–B	1917	275	313
Webb, Sask.	132–C	1914	230	241
Webbwood, Ont.	585	1916	155	181
Welland, Ont.	213	1913	64	85
Welland Jct., Ont.	214	1913	64	85
Westchester, N.S.	CMLX	1916	‡	172
Westfort, Ont.	89–E	1916	161	184
West Huntingdon, Ont.	181–G	1917	257	301
West Merigomish, N.S.	163–B	1913	47	74
Westmount, Que.	810	1918	13	35
Weston, Ont.	256–A	1913	58	82
West Toronto, Ont.	238–G *to* 241–G	1919	16, 17	25
Weyburn, Sask.	80–C, 81–C	1913	70	89
Whitby, Ont.	180–A, 926, 927	1919	16	24
Whitefish Lake, Que.	487	1914	219	234

‡ Refer to Public Works Dept.

ALPHABETICAL LIST OF CITIES, TOWNS AND VILLAGES AT OR NEAR WHICH BENCH-MARKS HAVE BEEN ESTABLISHED—*Concluded.*

Place	B.M. Number	Year of Publication	Description	Elevation
			Page	Page
Whitehorse, Y.T.	*1*	1912	25	25
Whitemouth, Man.	14–F	1915	18	33
White Pass, B.C.	*42–R, 43–R*	1912	23	23
White River, Ont.	723, 723–A	1918	18	39
Whiterock, B.C.	17–J, 18–J	1916	169	190
Whitewater, Man.	35–C	1913	68	88
Whitney, Ont.	536	1915	15	31
Wilcox, Sask.	86–C, 87–C	1913	70	89
Williamstown, Ont.	890	1919	12	20
Wilmot, N.S.	485–B	1916	148	175
Winchester, Ont.	109	1917	285	320
Windsor, Ont.	255	1913	57	81
Windsor, N.S.	502–B *to* 505–*B*	1916	149	176
Windsor Jct., N.S.	MXXXIV	1916	‡	171
Windsor Mills, Que.	644–B, 645–B	1918	10	33
Wingham, Ont.	314	1913	61	83
Winnifred, Alta.	176–C	1915	23	35
Winnipeg, Man.	1–F, 2–F, 3–F	1915	17	33
Winona, Ont.	202	1913	63	85
Winter, Sask.	25–H	1915	20	34
Wolfville, N.S.	495–B *to* 497–B	1916	148, 149	175
Woodstock, Ont.	226, 227	1913	55	80
Woodstock, N.B.	25–B, 26–B, 27–B	1917	276	313
Worthington, Ont.	577	1916	154	181
Wounded Moose, Y.T.	*179*	1912	33	33
Yahk, B.C.	187–D	1917	267	307
Yamachiche, Que.	708–B	1919	10	19
Yarmouth, N.S.	463–B, 464–B, 465–B	1915	13	30
Yellow Grass, Sask.	83–C	1913	70	89
Yukon Crossing, Y.T.	*94*	1912	29	29
Zumbro, Sask.	27–H	1915	20	34

‡ Refer to Public Works Dept.

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